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(12) **United States Patent**
Yoshida et al.

(10) **Patent No.: US 9,318,882 B2**
(45) **Date of Patent: Apr. 19, 2016**

(54) **INVERTER DEVICE**

(71) Applicant: **FUJI ELECTRIC CO., LTD.**, Kawasaki-shi (JP)

(72) Inventors: **Toshihiro Yoshida**, Suzuka (JP); **Tomokazu Yoshikawa**, Yokkaichi (JP)

(73) Assignee: **FUJI ELECTRIC CO., LTD.**, Kawasaki-shi (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 100 days.

(21) Appl. No.: **14/131,780**

(22) PCT Filed: **Oct. 26, 2012**

(86) PCT No.: **PCT/JP2012/077771**
§ 371 (c)(1),
(2) Date: **Jan. 9, 2014**

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PCT Pub. Date: **May 10, 2013**

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(30) **Foreign Application Priority Data**

Oct. 31, 2011 (JP) 2011-239734

(51) **Int. Cl.**
H02B 1/20 (2006.01)
H02B 1/01 (2006.01)
H05K 7/14 (2006.01)
H02M 7/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H02B 1/012*** (2013.01); ***H02M 7/003*** (2013.01); ***H05K 7/1432*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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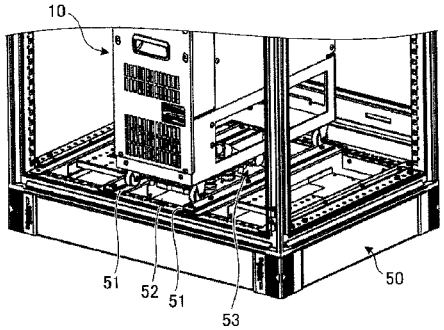
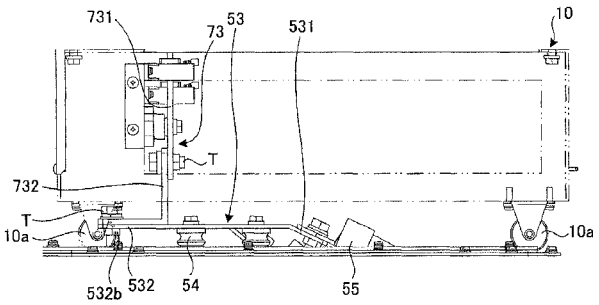
Primary Examiner — Courtney Smith
(74) *Attorney, Agent, or Firm* — Manabu Kanesaka

(57) **ABSTRACT**

An inverter device has an inverter stack and a switchboard housing the inverter stack. The inverter stack has an output relay bar connected to an output terminal thereof, and a lower frame configuring a bottom portion and formed from a plurality of frame members connected to form each side of a cuboid. The lower frame is formed such that the frame members configuring one side of a four-sided frame being penetrated by the output relay bar are formed of a non-magnetic body.

7 Claims, 29 Drawing Sheets





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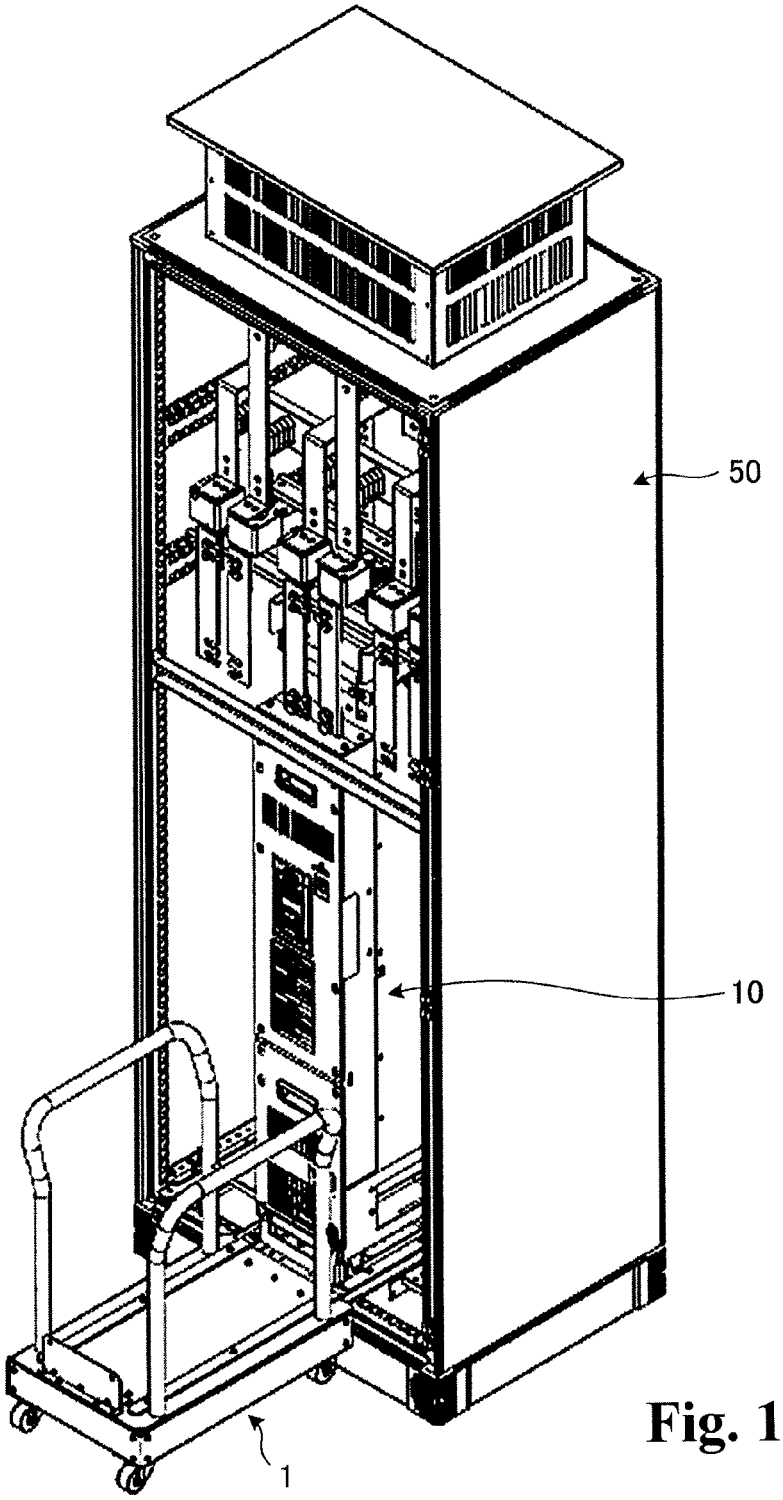

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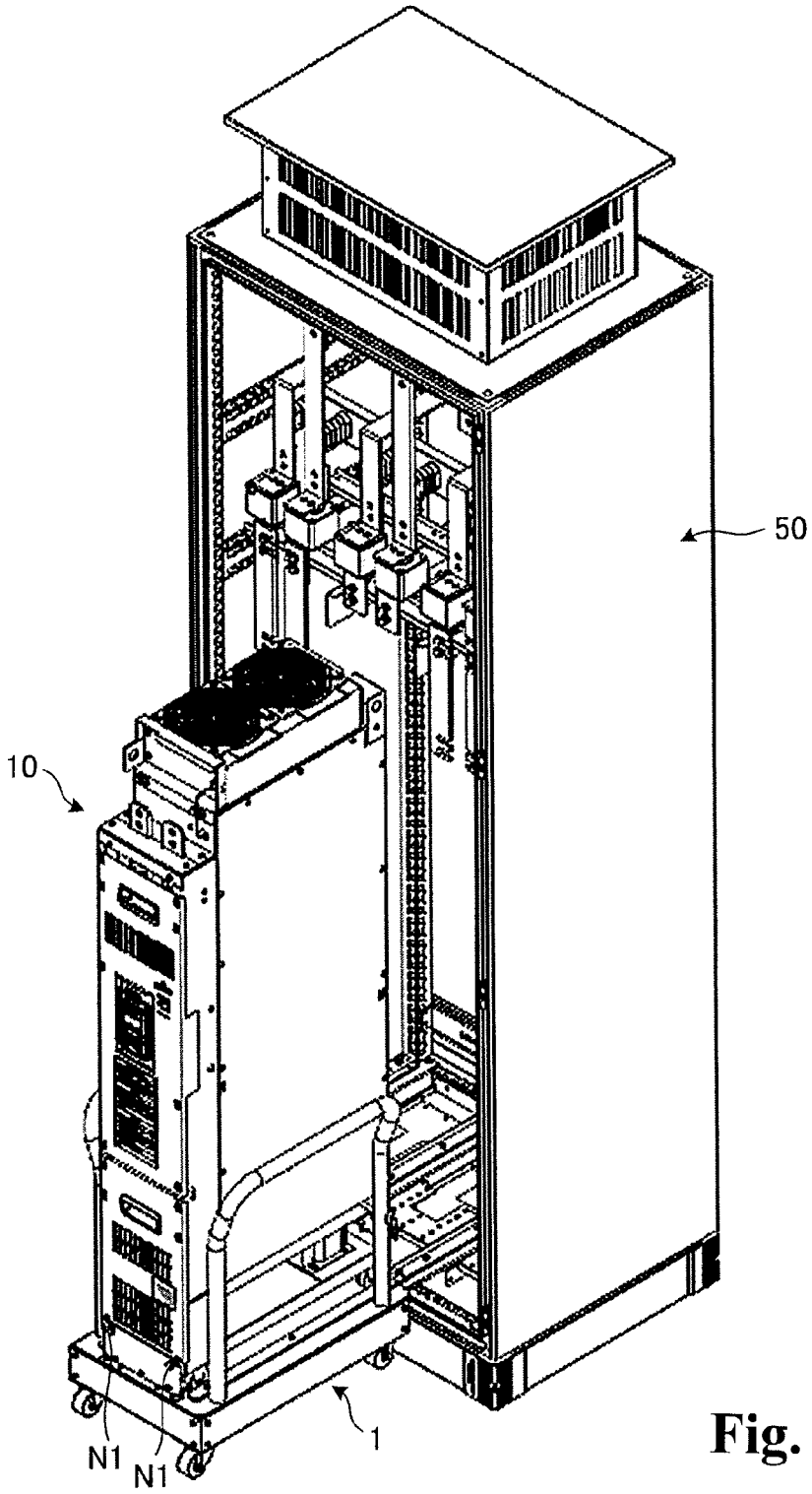

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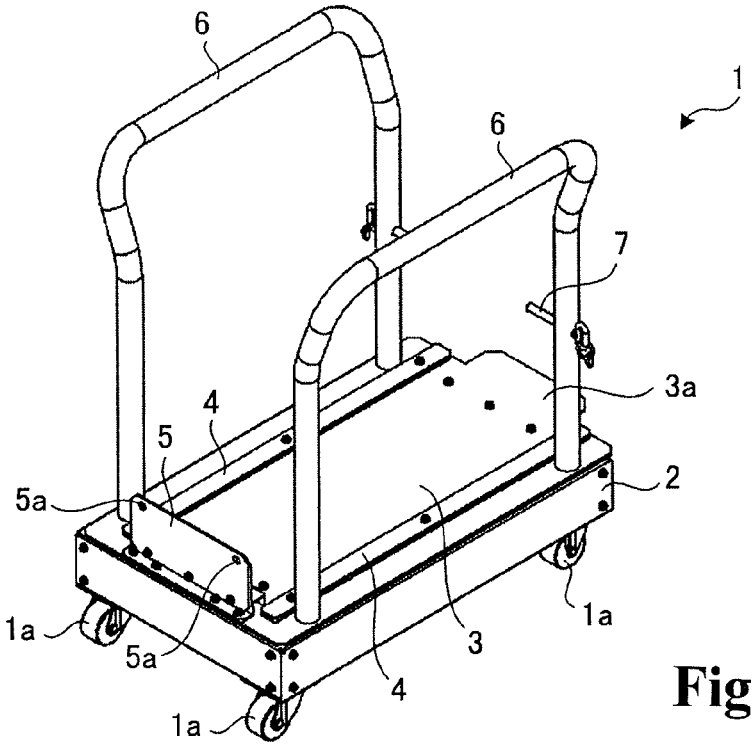

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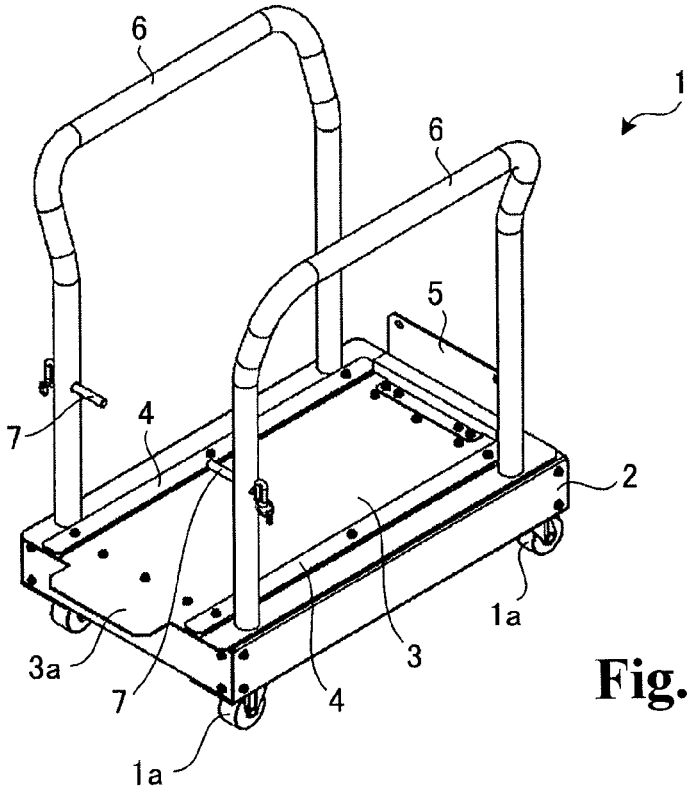

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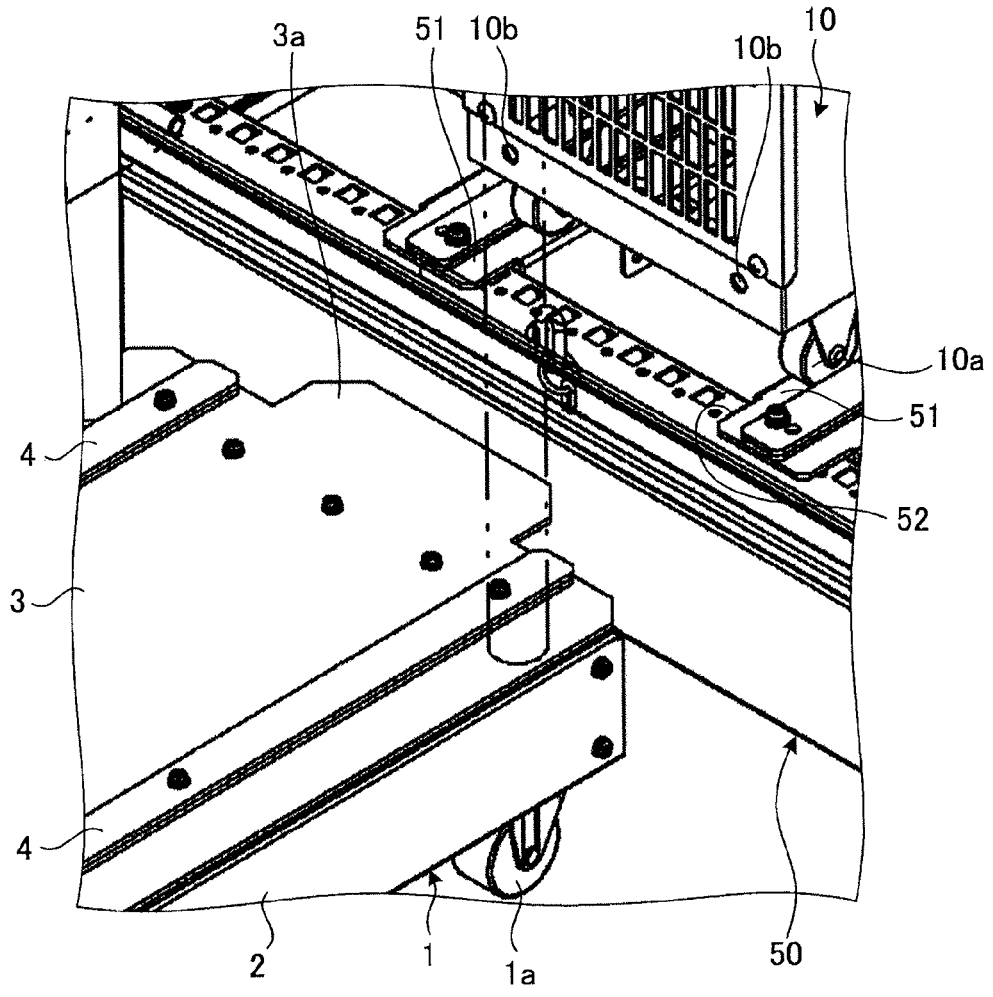

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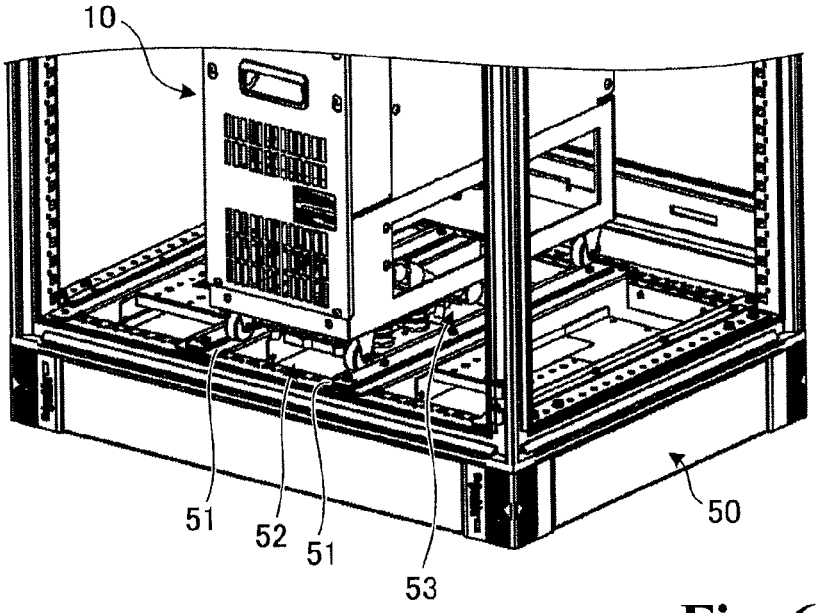
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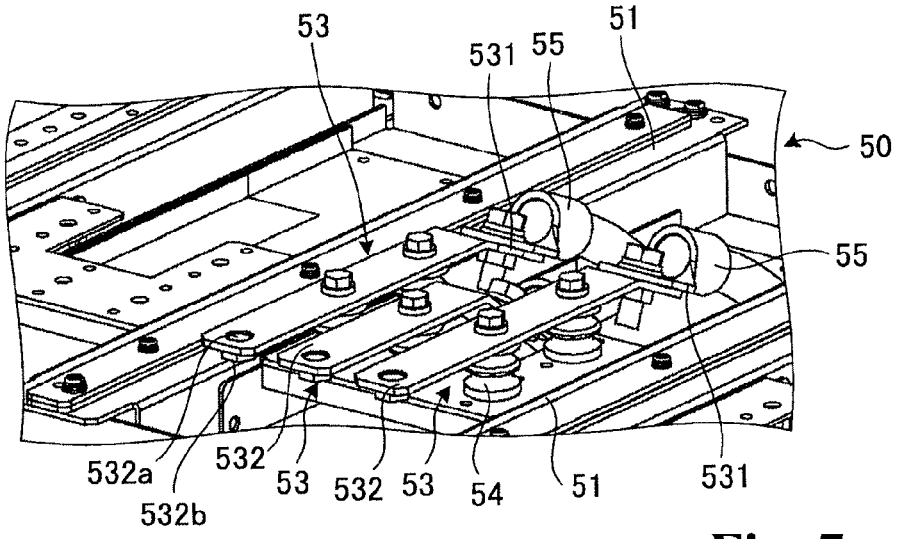
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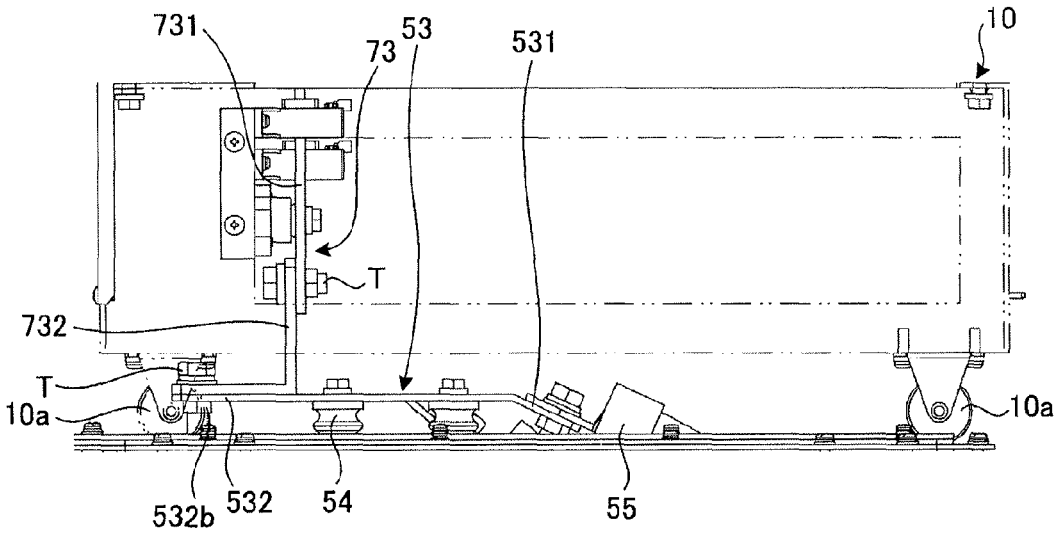

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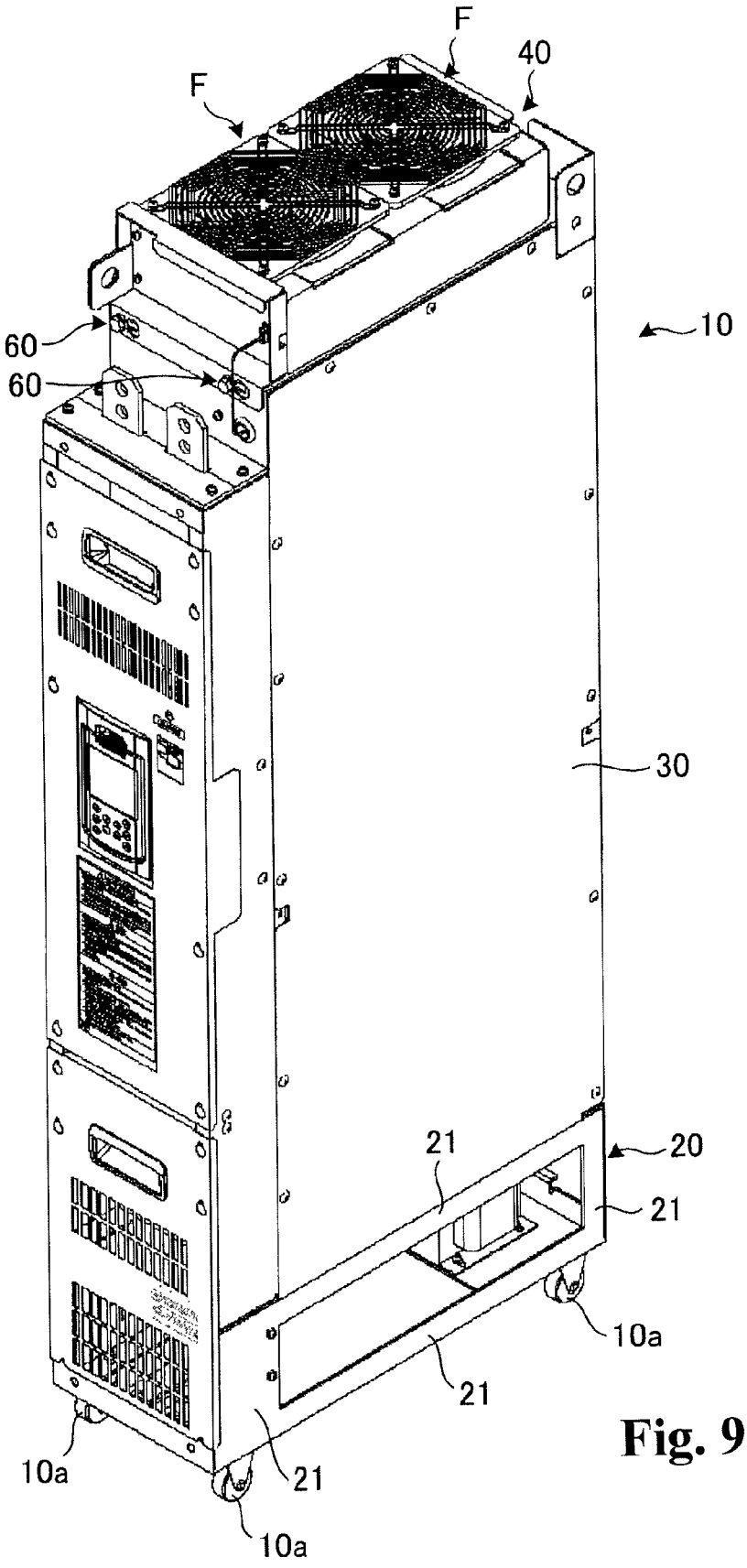

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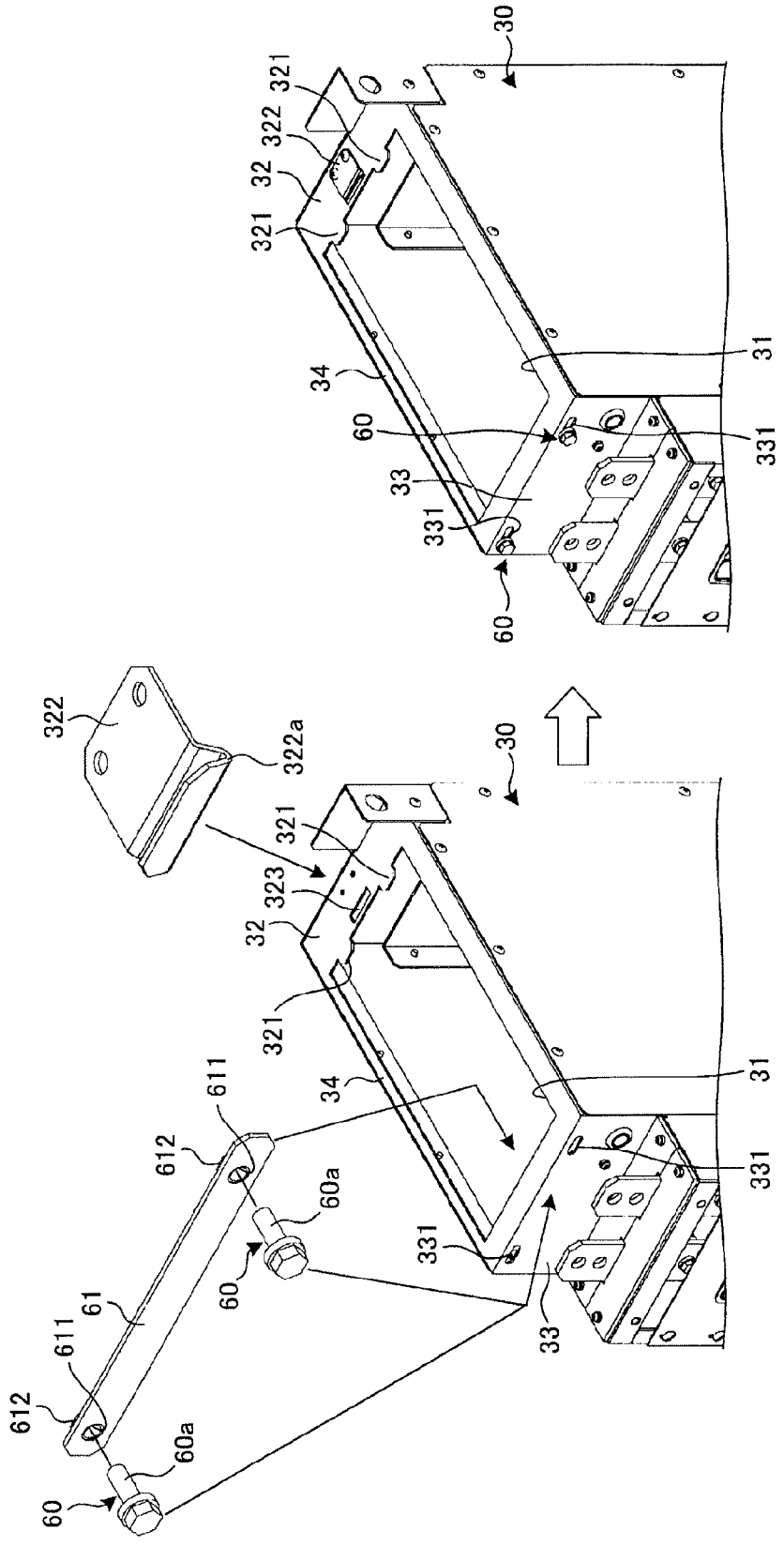
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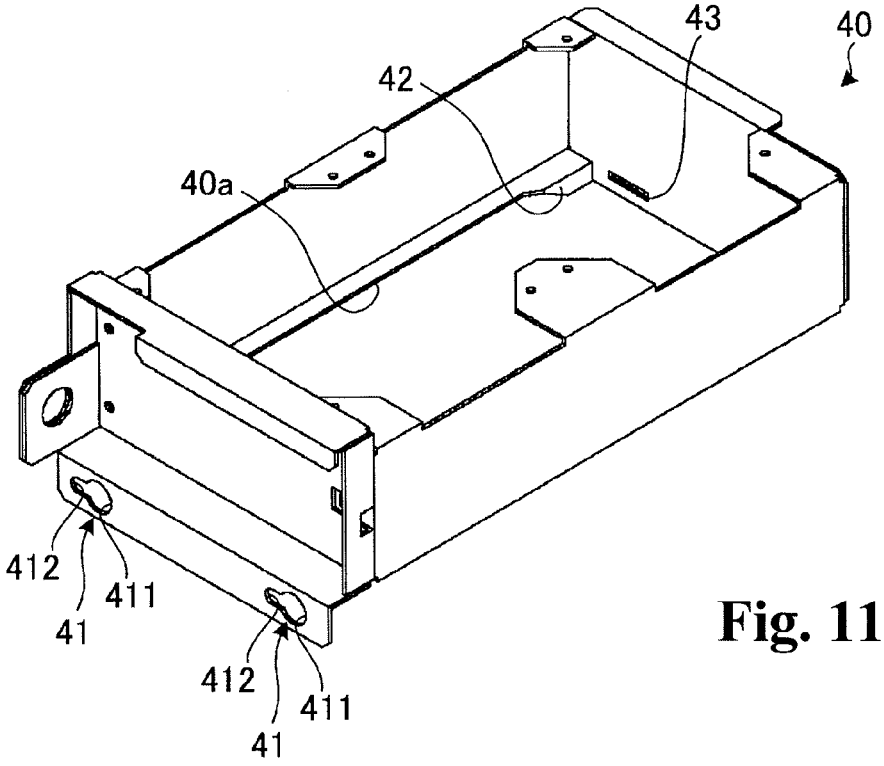
Fig. 10



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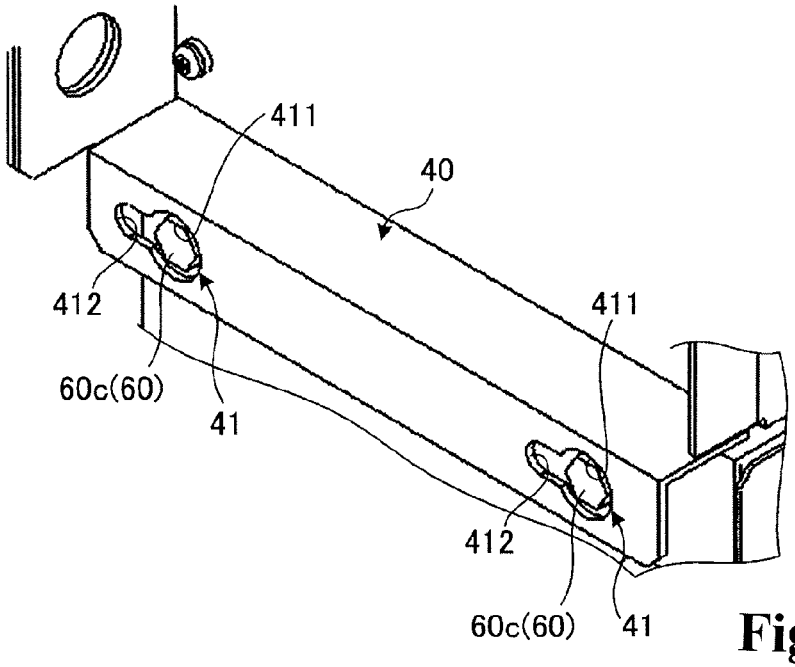
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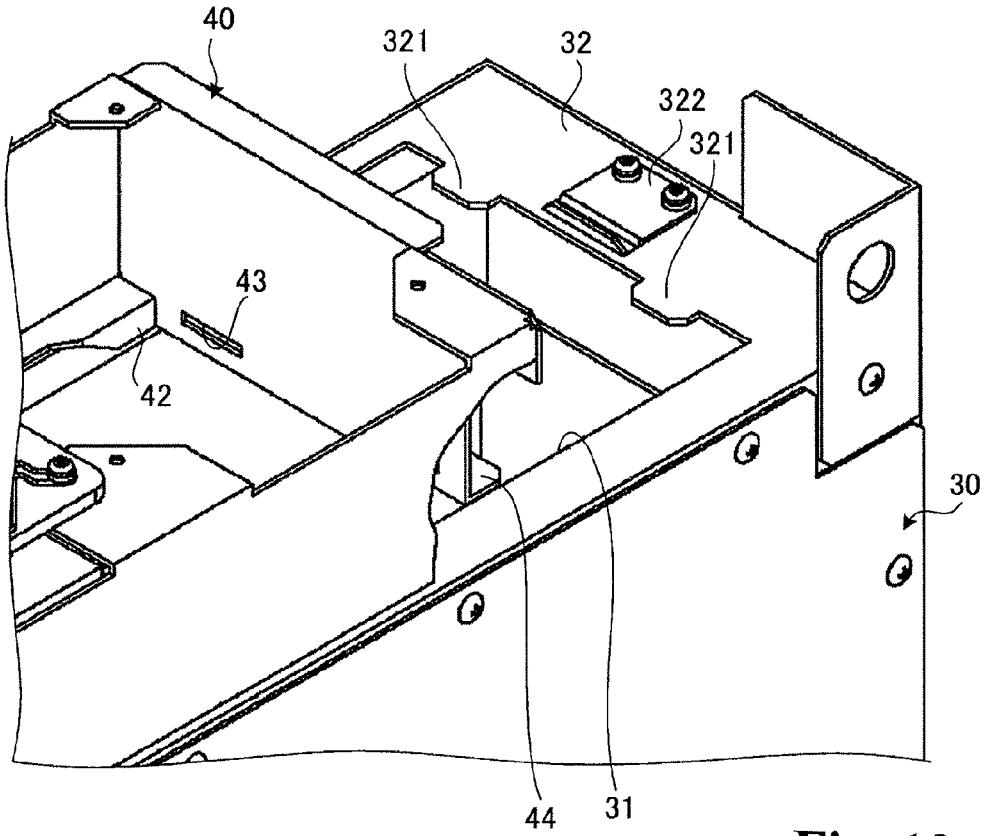
Fig. 12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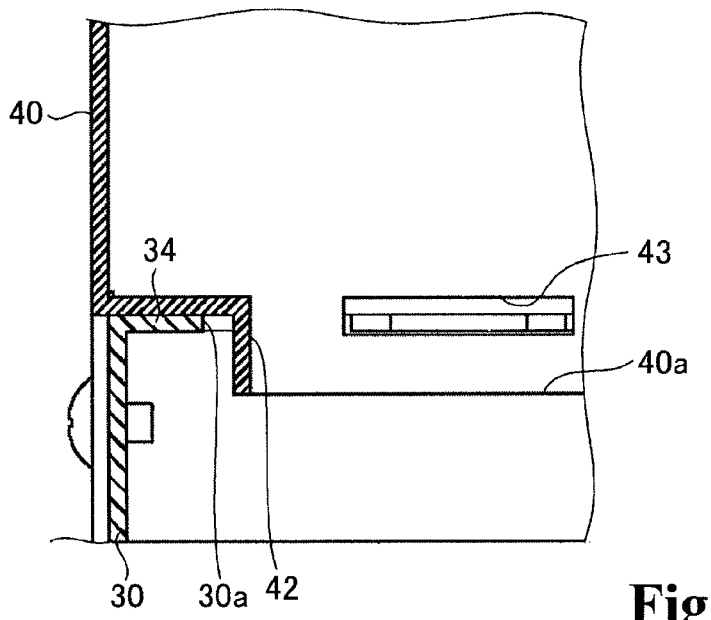

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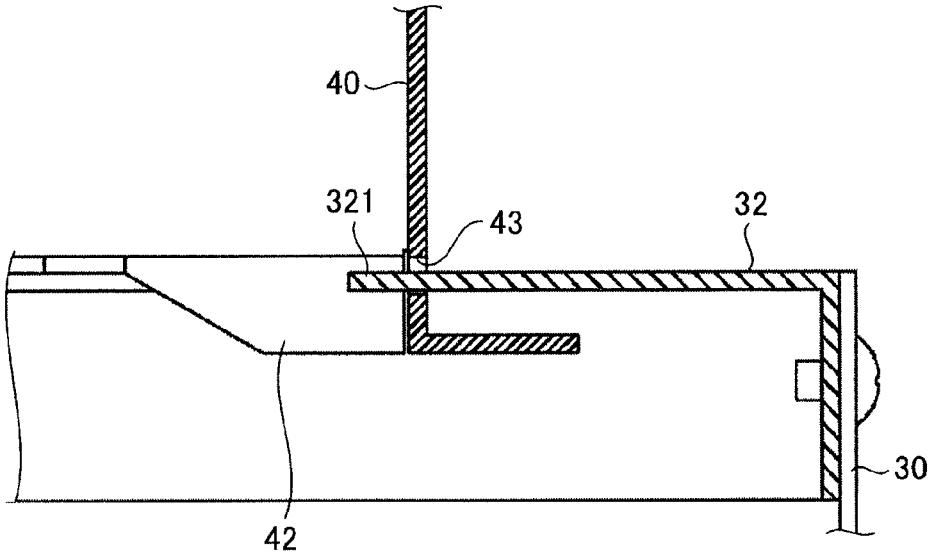

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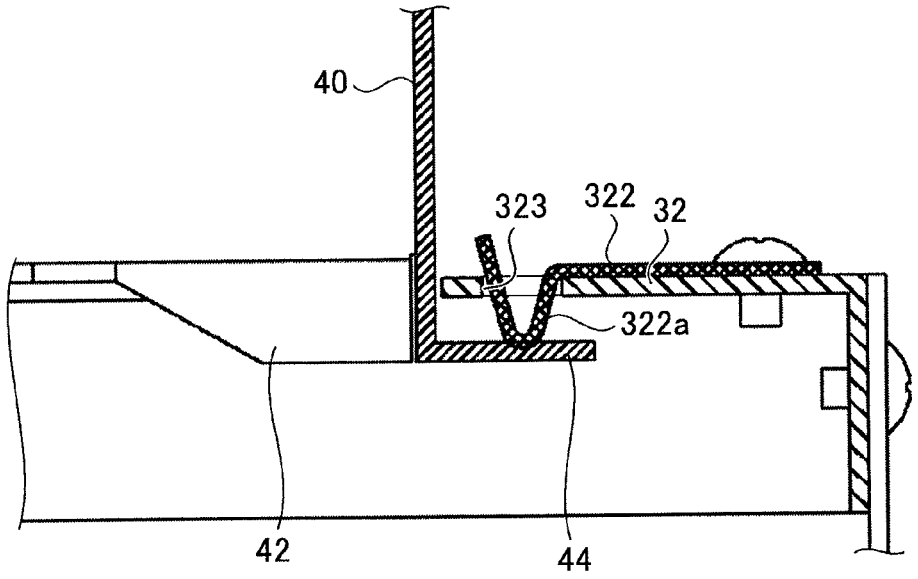

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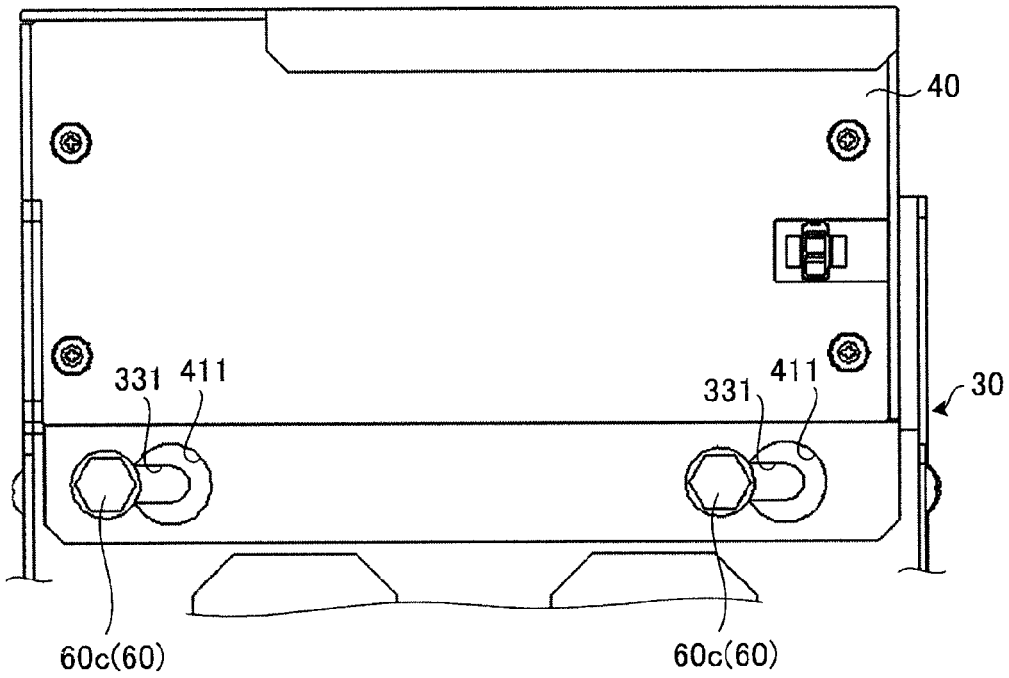

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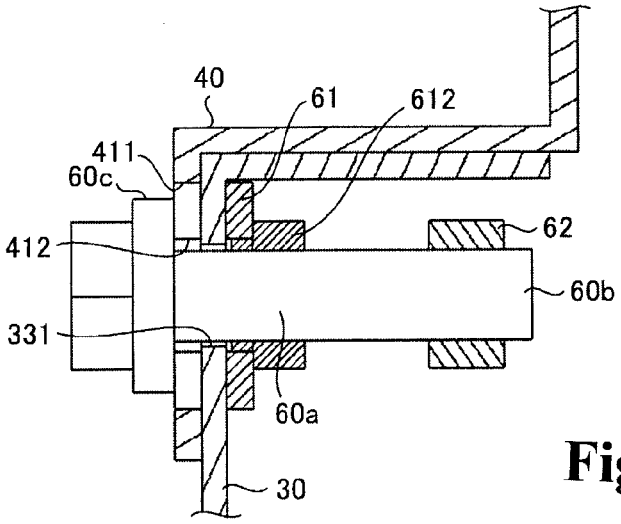
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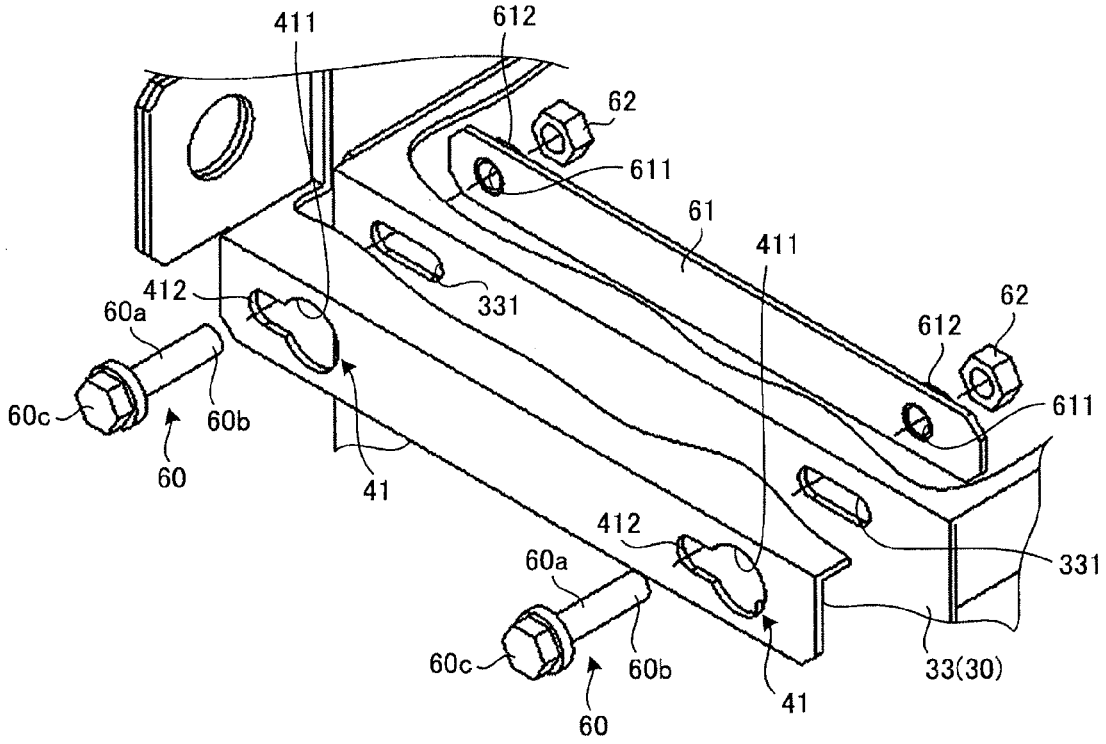
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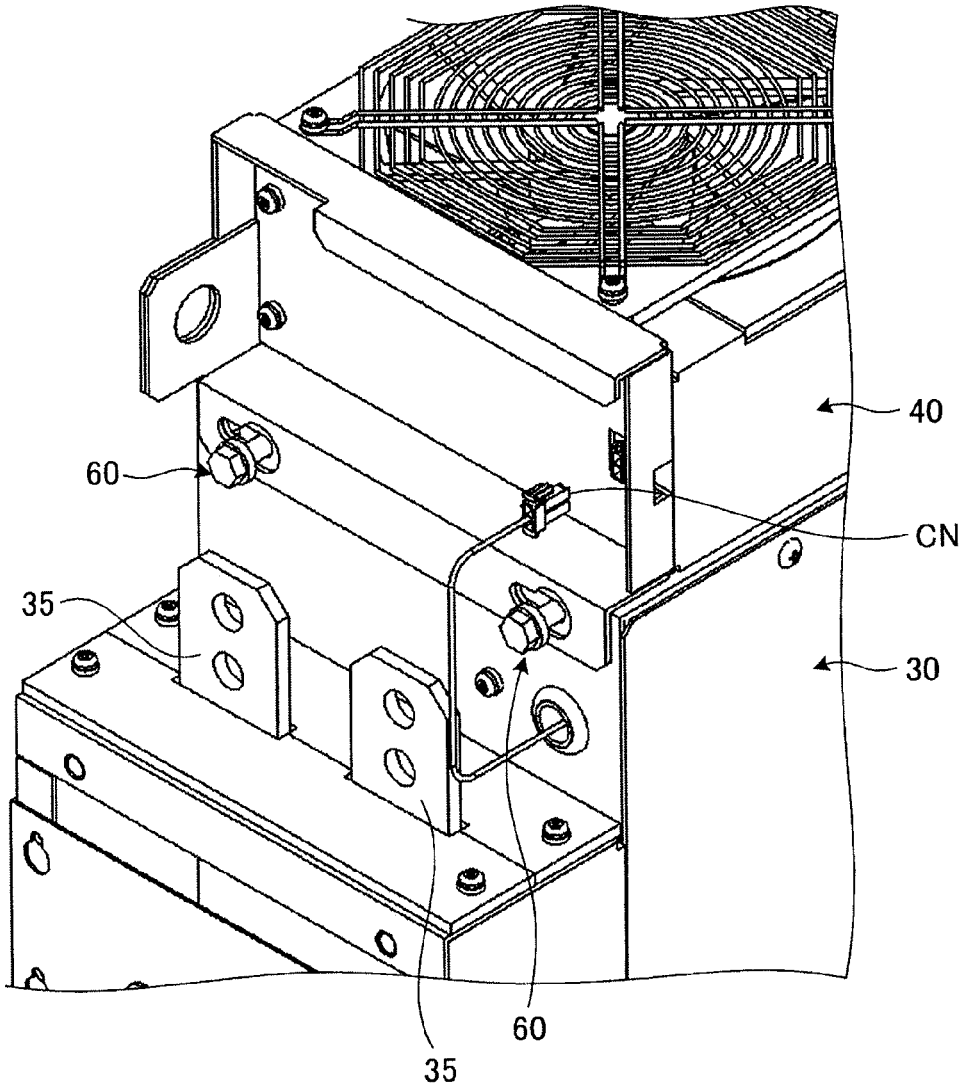

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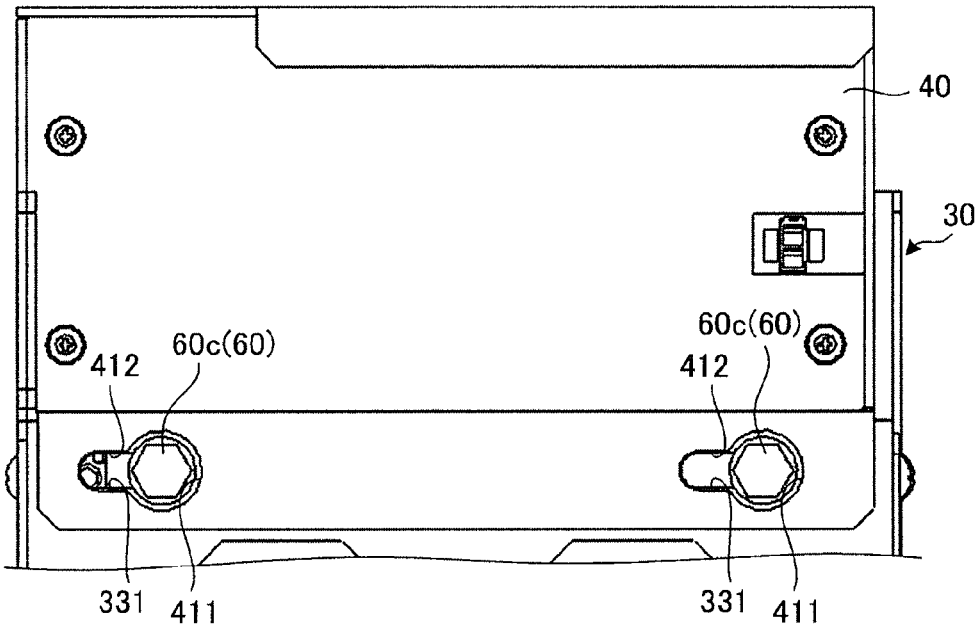

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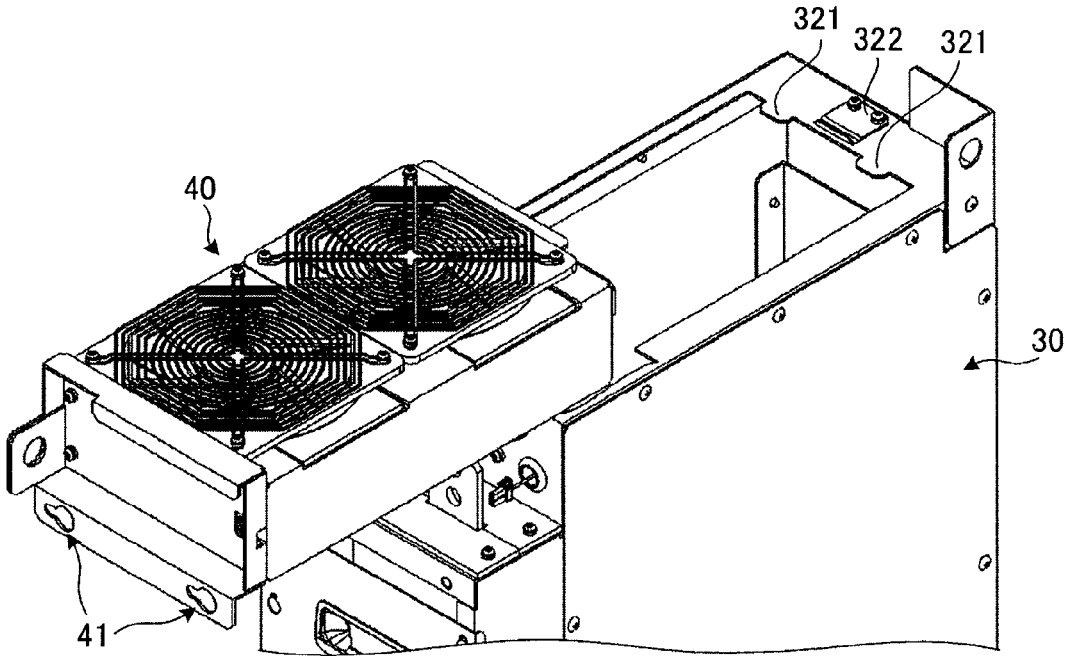

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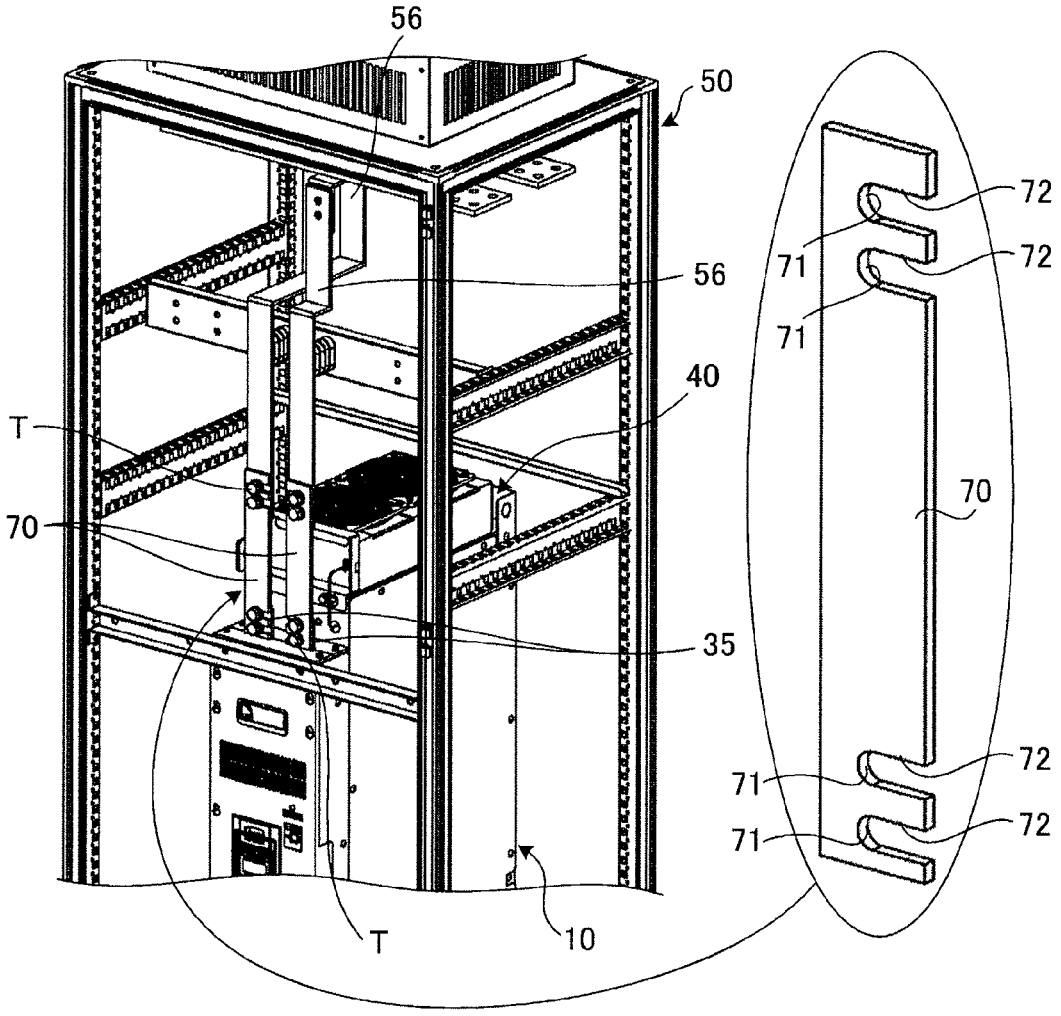

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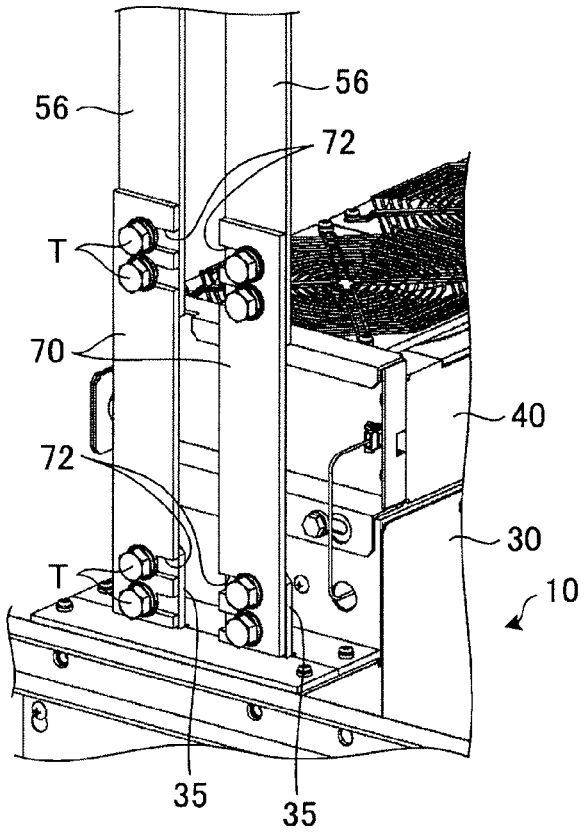

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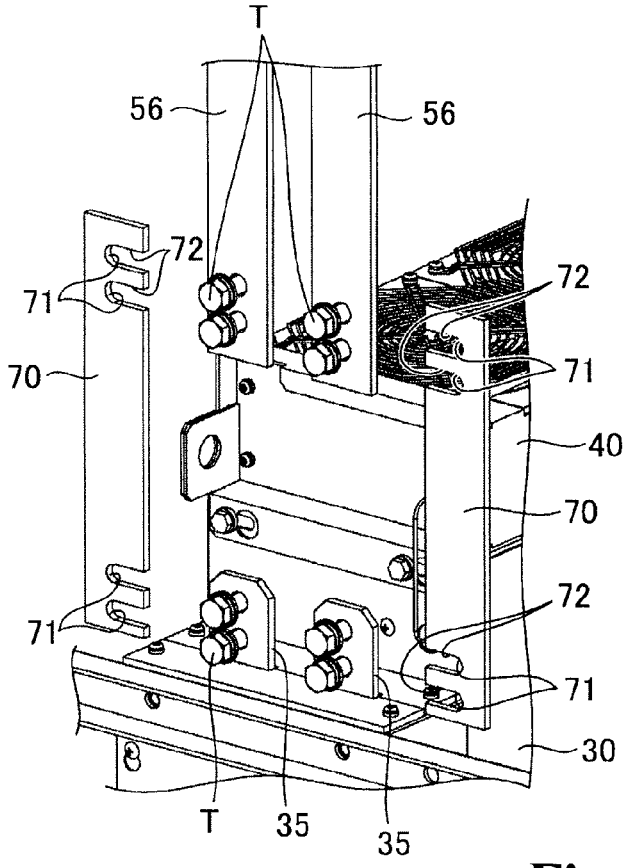

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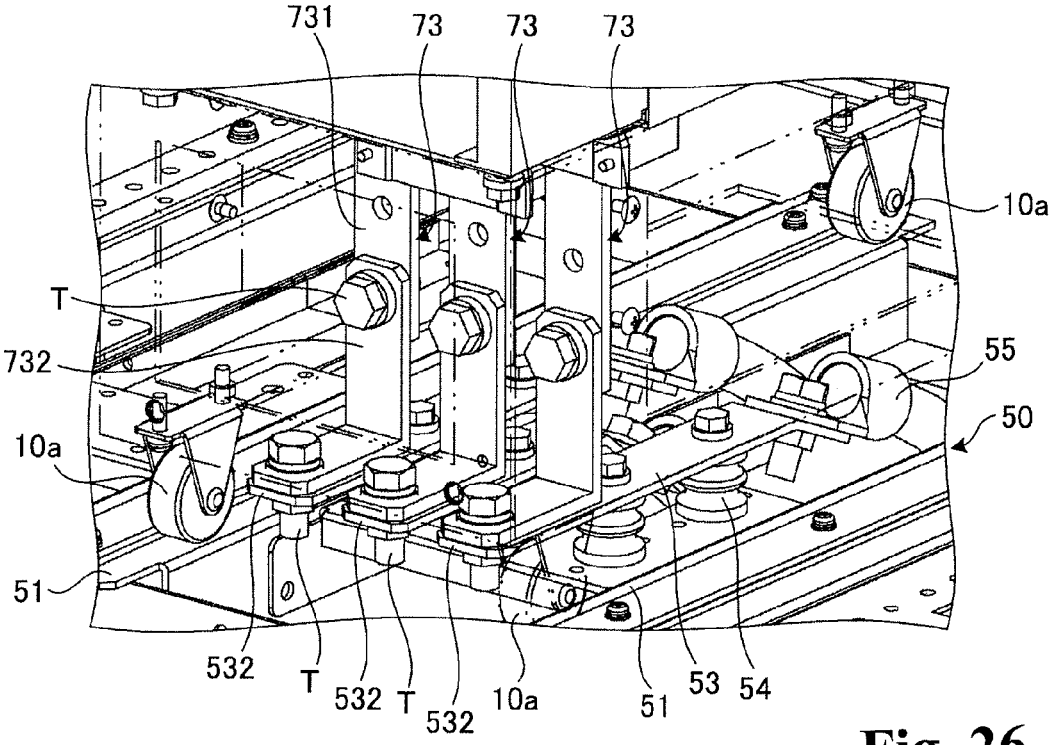
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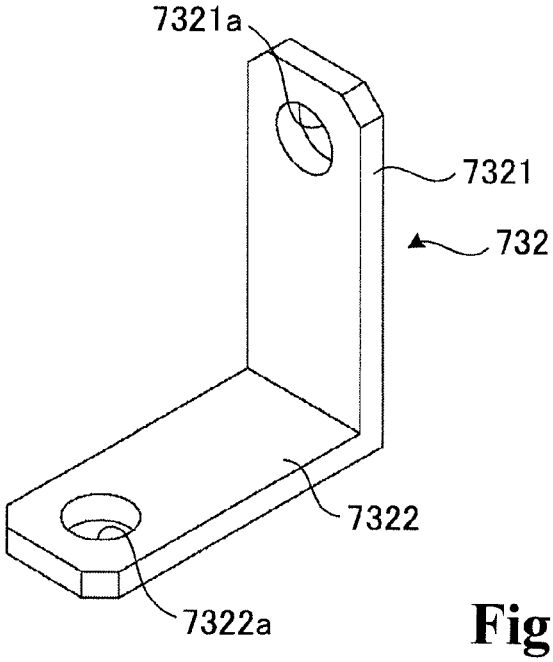
Fig. 26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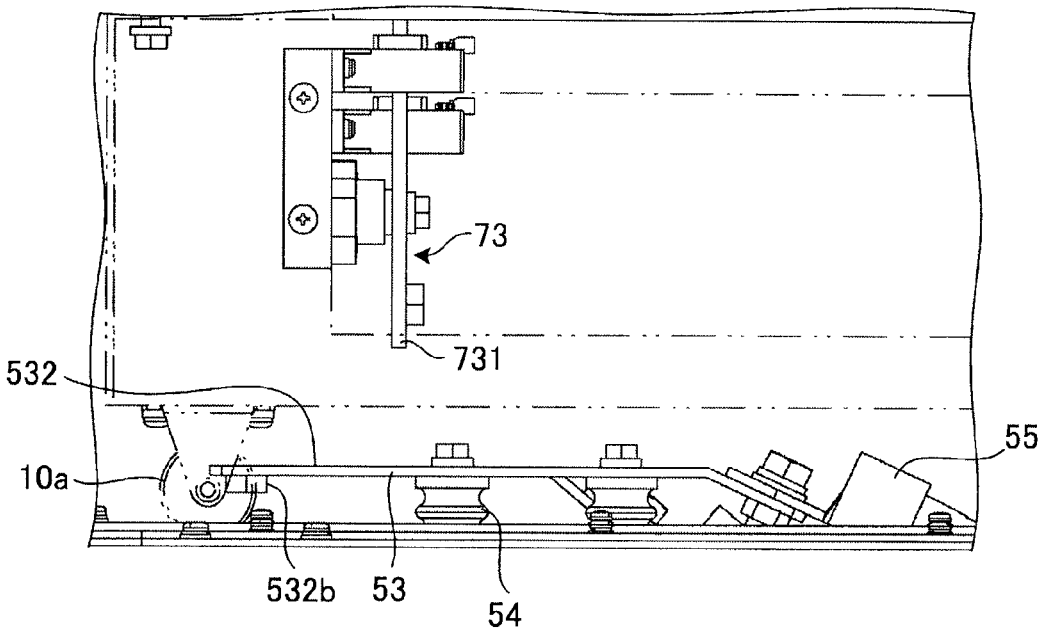

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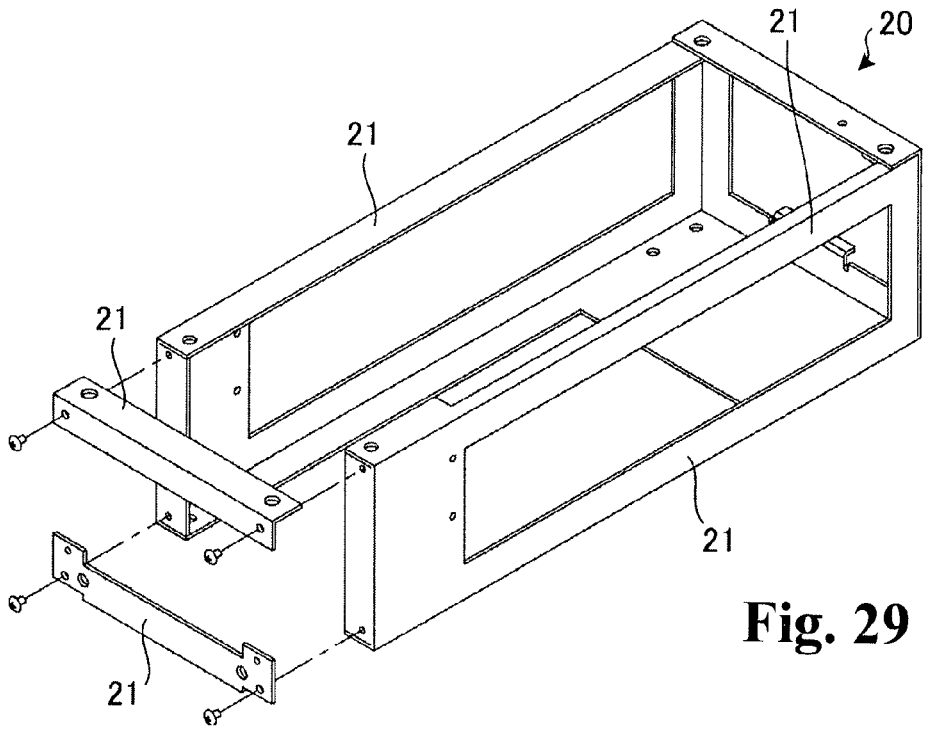

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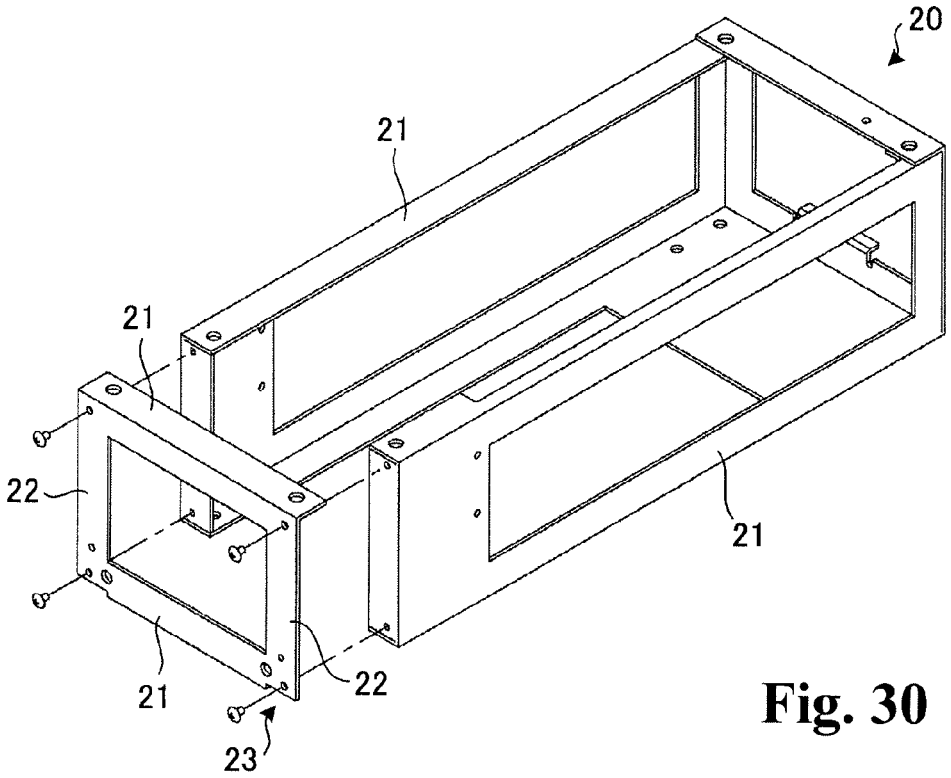

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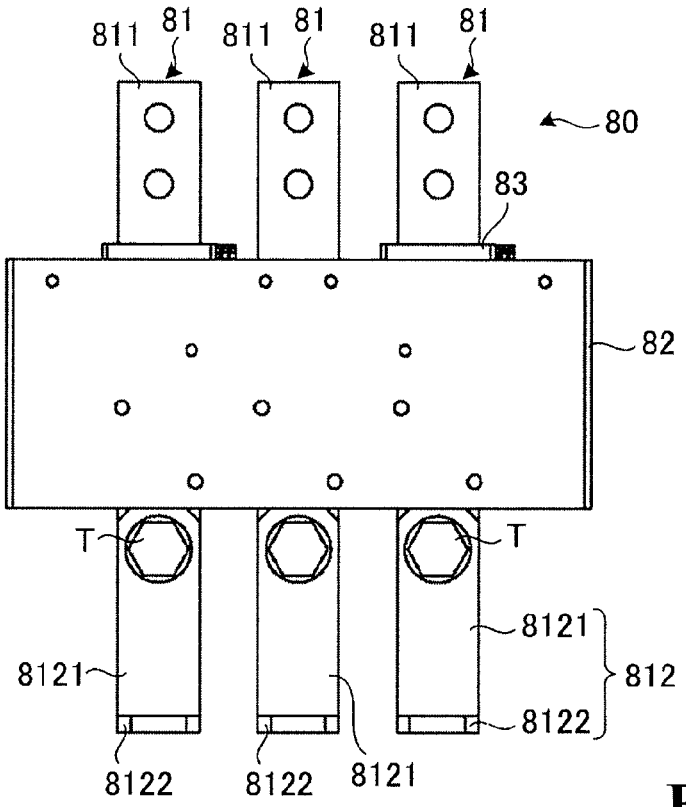
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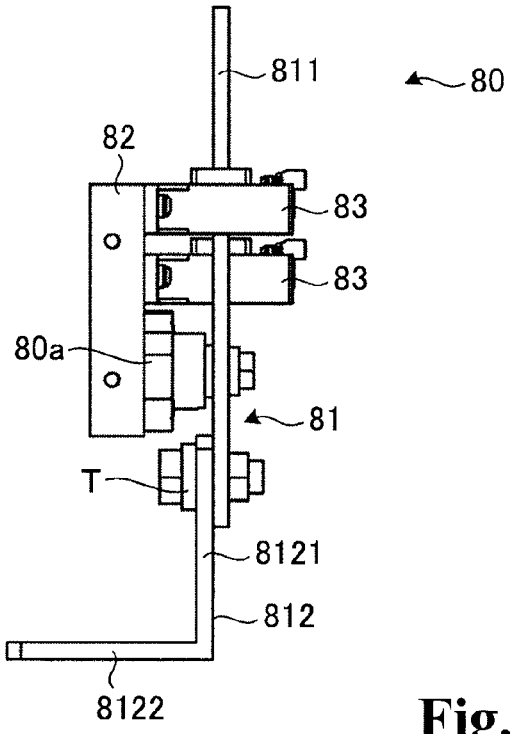
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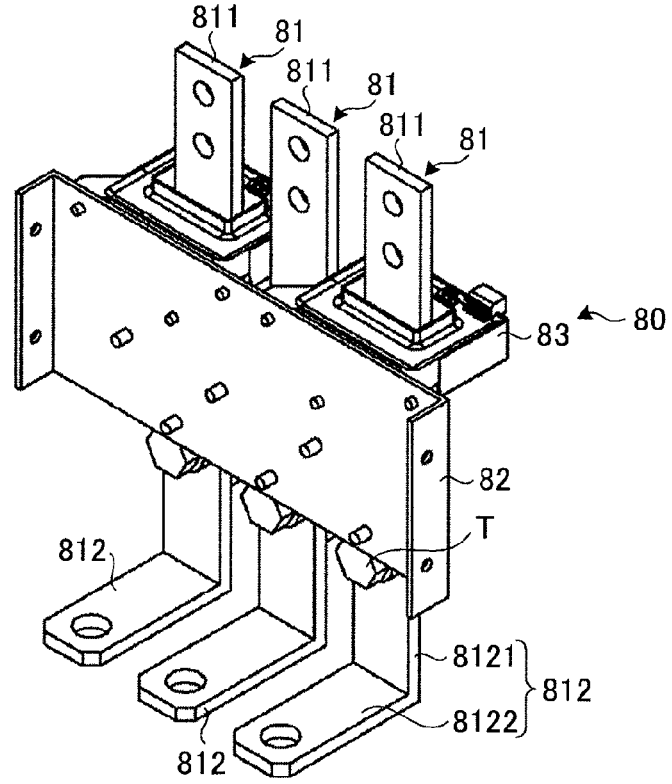
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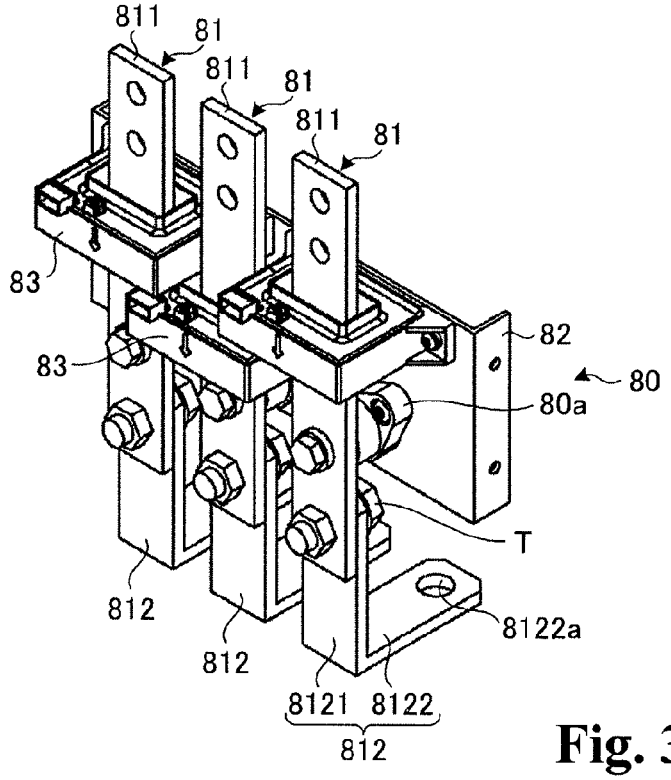
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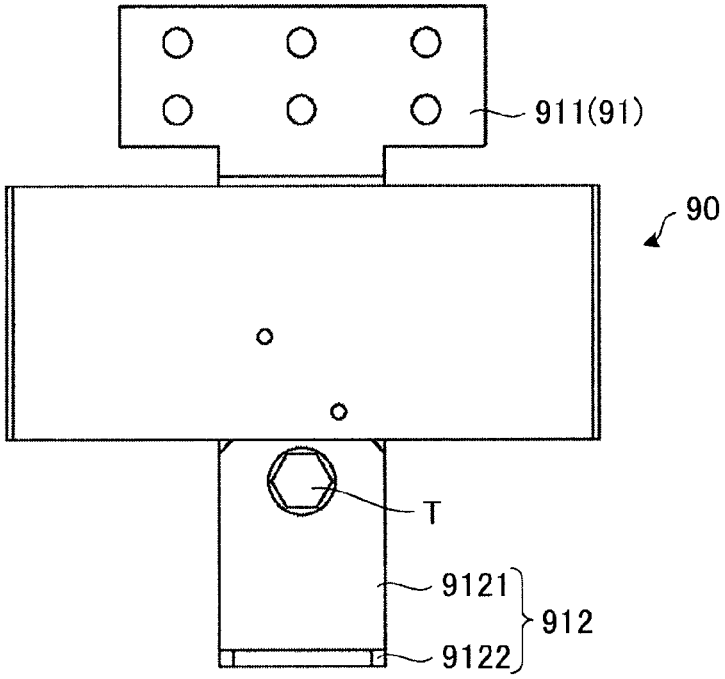

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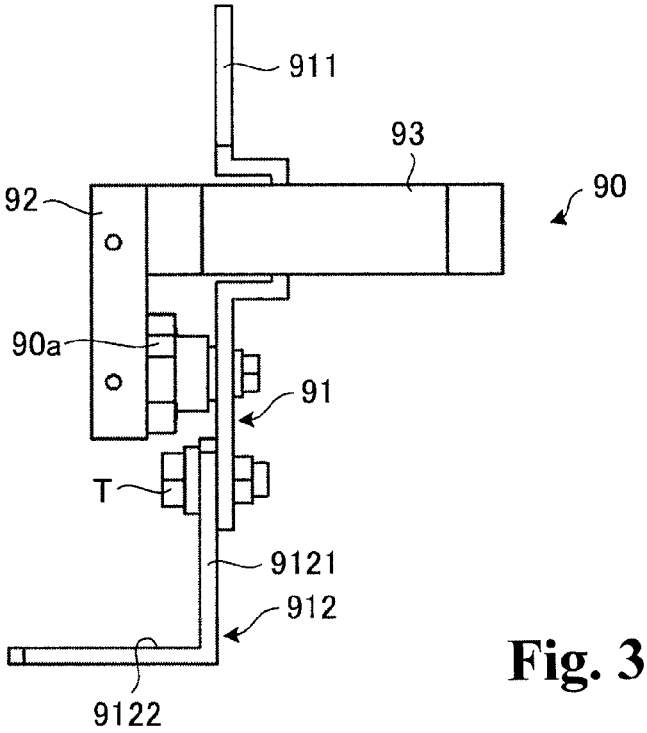

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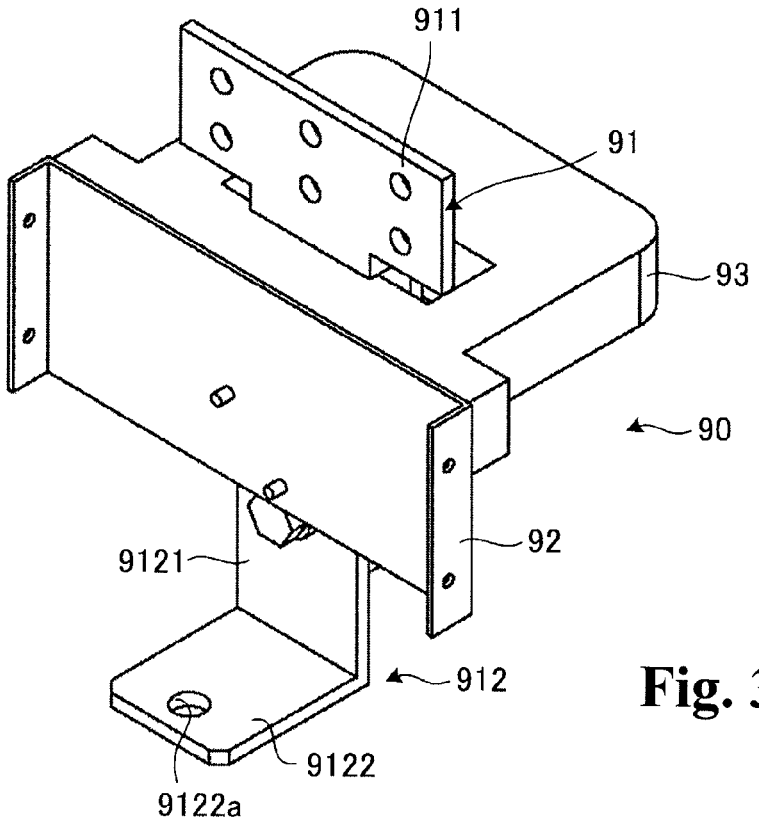

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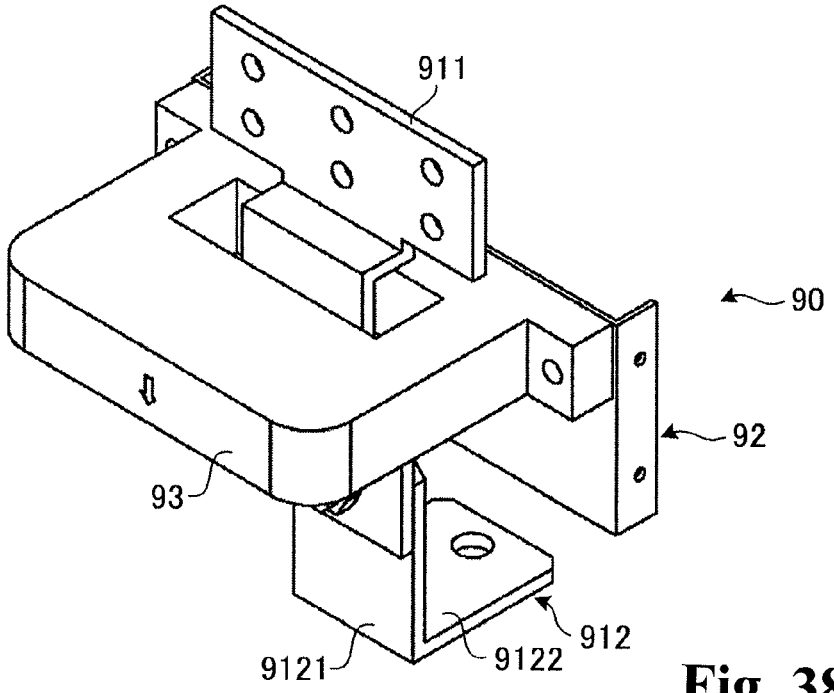

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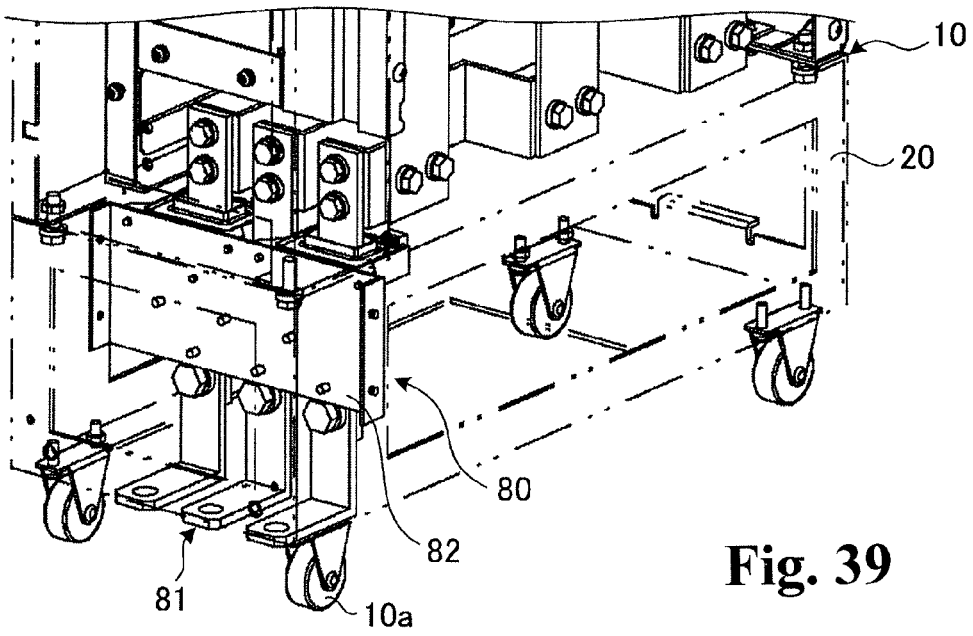

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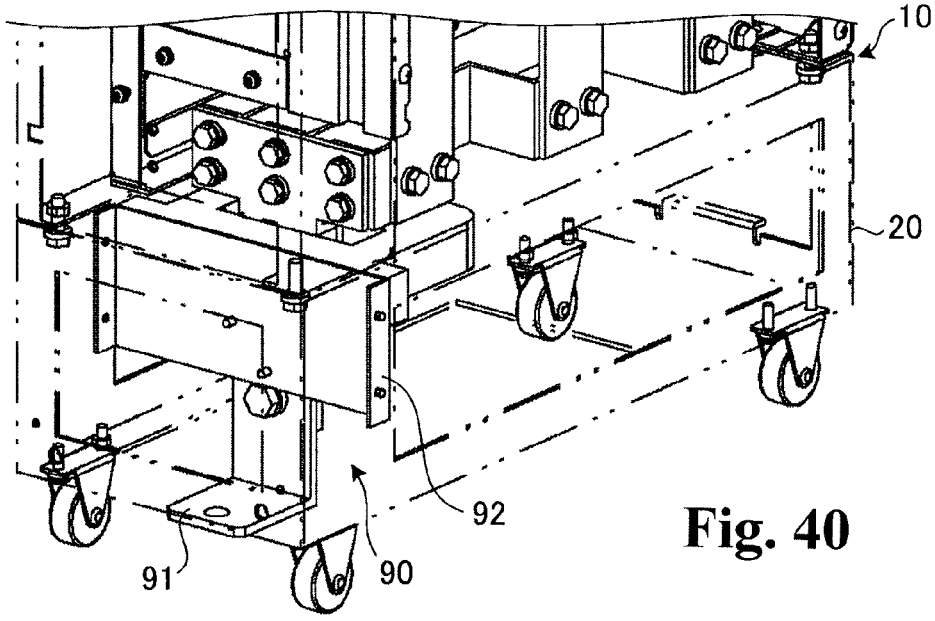
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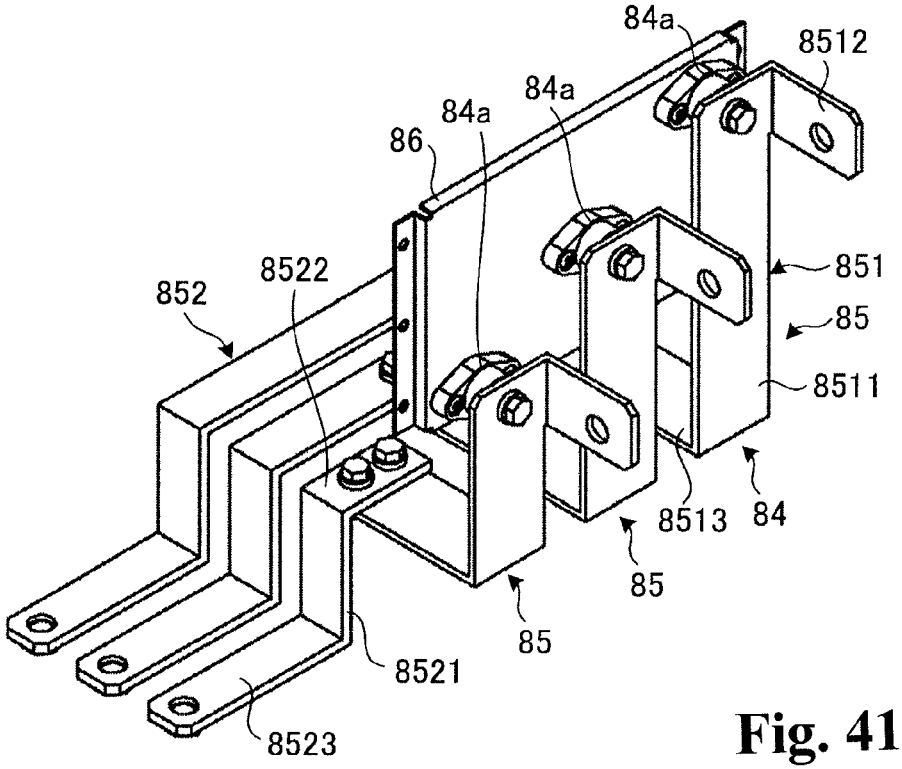
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Fig. 41

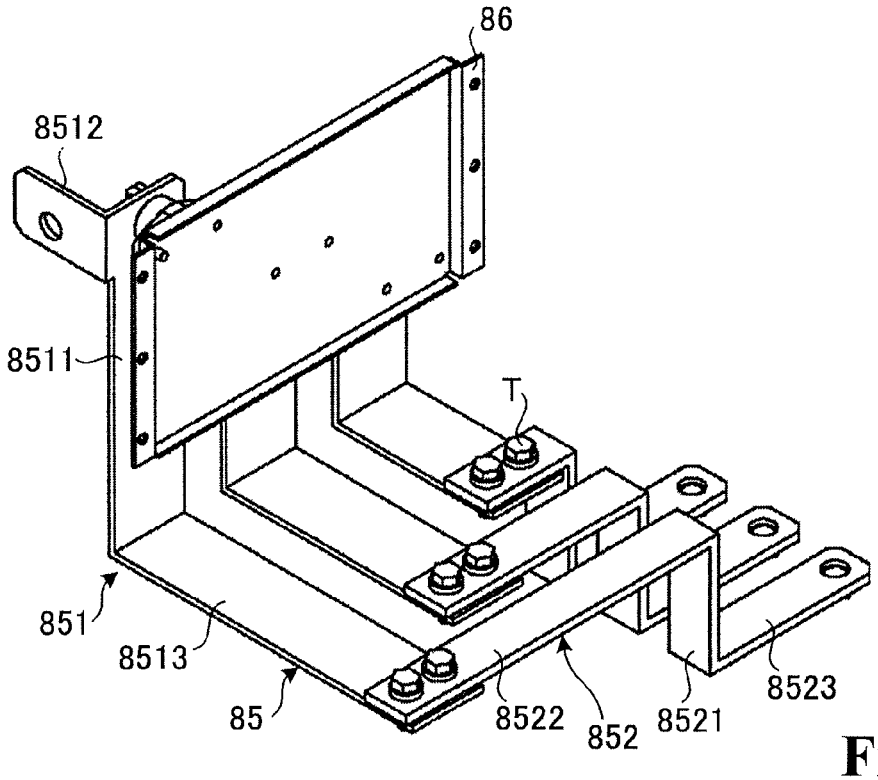
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Fig. 42

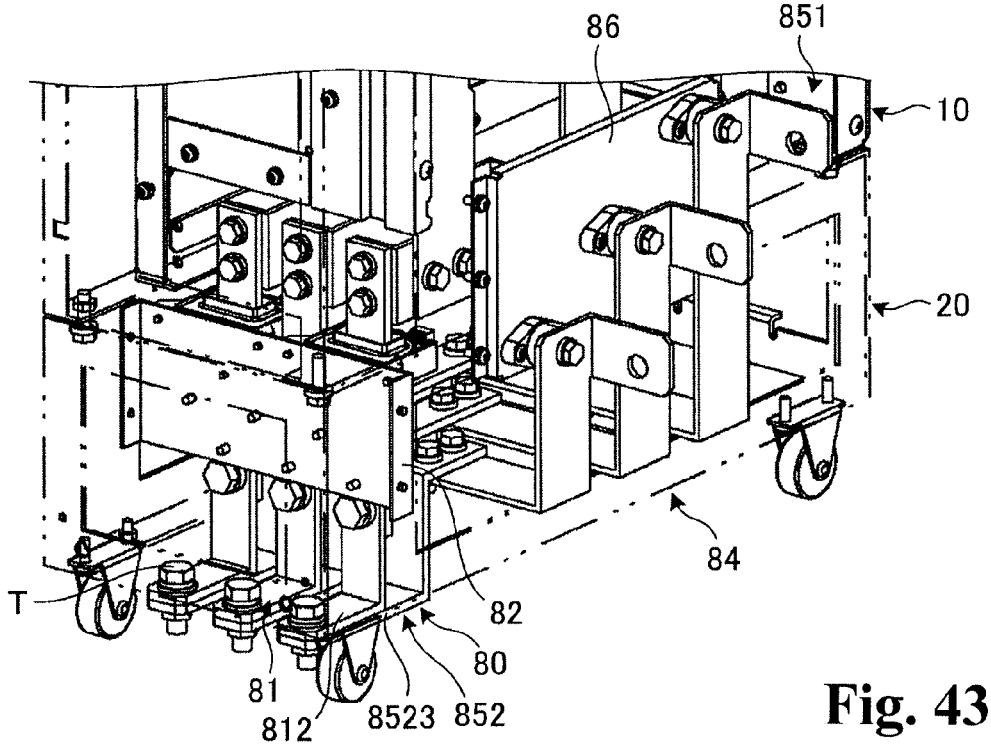
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Fig. 43

INVERTER DEVICE

RELATED APPLICATIONS

The present application is National Phase of International Application No. PCT/JP2012/077771 filed Oct. 26, 2012, and claims priority from Japanese Application No. 2011-239734 filed Oct. 31, 2011.

TECHNICAL FIELD

The present invention relates to an inverter device, and more specifically, relates to an inverter device including an inverter stack having casters on a bottom portion thereof and a switchboard in which the inverter stack is housed by being entered from the front.

BACKGROUND ART

A heretofore known inverter device includes an inverter stack having casters on a bottom portion thereof and a switchboard in which the inverter stack is housed by being entered from the front (for example, refer to Patent Literature 1).

CITATION LIST

Patent Literature

Patent Literature 1: JP-A-H07-123539

SUMMARY OF INVENTION

Technical Problem

Although not clearly indicated in Patent Literature 1, the heretofore known inverter device is configured such that an output terminal of the inverter stack and an output relay terminal forming a switchboard, and to which an output wire connected to a load is attached, are linked by a plate-shaped output relay bar. Further, the inverter stack configuring the inverter device is formed such that a lower frame that configures a bottom portion, and which is passed through the output relay bar, is formed of stainless steel or the like, which is a non-magnetic body, with a view to prevent heating and vibration due to the occurrence of an overcurrent, or the like. The stainless steel is expensive compared to a steel plate or the like, which leads to an increase in the manufacturing cost of an inverter device that includes an inverter stack having this kind of lower frame.

The invention, bearing in mind the heretofore described situation, has an object of providing an inverter device such that it is possible to achieve a reduction in manufacturing cost while preventing heating and vibration due to the occurrence of an overcurrent, or the like.

Solution to Problem

In order to achieve the object, an inverter device according to the first aspect of the invention relates to an inverter device including an inverter stack and a switchboard that houses the inverter stack. The inverter stack has an output relay bar linked to its own output terminal, and a lower frame configuring a bottom portion and formed of a plurality of frame members linked so as to form the sides of a cuboid. The lower frame is formed such that frame members configuring one side of a four-sided frame through which the output relay bar passes are formed of a non-magnetic body.

Advantageous Effects of Invention

According to the invention, the inverter stack has an output relay bar linked to its own output terminal, and a lower frame configuring a bottom portion and formed of a plurality of frame members linked so as to form the sides of a cuboid, and the lower frame is formed such that frame members configuring one side of a four-sided frame through which the output relay bar passes are formed of a non-magnetic body, because of which it is possible to control the occurrence of an overcurrent, and thus possible to prevent heating and vibration due to the occurrence of an overcurrent, or the like. Also, as it is possible to configure the other frame members of the lower frame of sheet-metal or the like, it is possible to reduce manufacturing cost in comparison with when forming all the frame members of a non-magnetic body such as stainless steel. Consequently, an advantage is achieved in that it is possible to achieve a reduction in manufacturing cost while preventing heating and vibration due to the occurrence of an overcurrent, or the like.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view showing an inverter device which is an embodiment of the invention.

FIG. **2** is a perspective view showing a state in which an inverter stack configuring the inverter device shown in FIG. **1** is conveyed by a transport cart.

FIG. **3** is a perspective view showing a state in which the transport cart applied to the inverter device shown in FIG. **1** and FIG. **2** is viewed from a front side.

FIG. **4** is a perspective view showing a state in which the transport cart applied to the inverter device shown in FIG. **1** and FIG. **2** is viewed from a rear side.

FIG. **5** is a perspective view showing an enlargement of a condition in which the transport cart is in close proximity of a switchboard.

FIG. **6** is a perspective view showing a housing bottom portion of the switchboard shown in FIG. **1** and FIG. **2** in which the inverter stack is housed.

FIG. **7** is a perspective view showing an enlargement of a main portion of the housing bottom portion shown in FIG. **6**.

FIG. **8** is an illustration showing a state in which the housing bottom portion of the switchboard shown in FIG. **6** is viewed from the side.

FIG. **9** is a perspective view showing the inverter stack configuring the inverter device shown in FIG. **1** and FIG. **2**.

FIG. **10** is an illustration showing the configuration of the upper surface of an inverter main body.

FIG. **11** is a perspective view showing the configuration of a fan block.

FIG. **12** is an illustration illustrating a procedure for disposing the fan block in the inverter main body.

FIG. **13** is an illustration illustrating a procedure for disposing the fan block in the inverter main body.

FIG. **14**, which illustrates a procedure for disposing the fan block in the inverter main body, is an enlarged sectional view showing a state in which a main portion is viewed from the front side.

FIG. **15**, which illustrates a procedure for disposing the fan block in the inverter main body, is an enlarged sectional view showing a state in which a main portion is viewed from the side.

FIG. **16**, which illustrates a procedure for disposing the fan block in the inverter main body, is an enlarged sectional view showing a state in which a main portion is viewed from the side.

FIG. **17** is a front view of the fan block disposed on an upper portion of the inverter main body.

FIG. **18** is an enlarged sectional side view of a main portion of the fan block disposed on an upper portion of the inverter main body.

FIG. **19** is an exploded perspective view of a main portion of the fan block disposed on an upper portion of the inverter main body.

FIG. **20** is an illustration for illustrating a procedure for removing the fan block from the inverter main body.

FIG. **21** is a front view for illustrating a procedure for removing the fan block from the inverter main body.

FIG. **22** is an illustration for illustrating a procedure for removing the fan block from the inverter main body.

FIG. **23** is a perspective view showing an input side connection condition of the inverter stack and switchboard.

FIG. **24** is an enlarged perspective view showing an enlargement of a main portion shown in FIG. **23**.

FIG. **25** is a perspective view showing a release of the input side connection condition of the inverter stack and switchboard.

FIG. **26** is a perspective view showing an output side connection condition of the inverter stack and switchboard.

FIG. **27** is a perspective view showing a second output relay bar configuring an output relay bar shown in FIG. **26**.

FIG. **28** is a side view showing a condition in which the second output relay bar configuring the output relay bar shown in FIG. **26** has been removed.

FIG. **29** is an illustration showing the configuration of a lower frame.

FIG. **30** is an illustration showing the configuration of a modification example of the lower frame.

FIG. **31** is a front view showing a first output relay unit.

FIG. **32** is a side view showing the first output relay unit.

FIG. **33** is a perspective view of the first output relay unit viewed from the front side.

FIG. **34** is a perspective view of the first output relay unit seen from the rear side.

FIG. **35** is a front view showing a second output relay unit.

FIG. **36** is a side view showing the second output relay unit.

FIG. **37** is a perspective view of the second output relay unit viewed from the front.

FIG. **38** is a perspective view of the second output relay unit viewed from behind.

FIG. **39** is an illustration showing a condition in which the first output relay unit shown in FIG. **31** to FIG. **34** is installed.

FIG. **40** is an illustration showing a condition in which the second output relay unit shown in FIG. **35** to FIG. **38** is installed.

FIG. **41** is a perspective view of an attachment member applicable to the first output relay unit shown in FIG. **31** to FIG. **34** viewed from a front side.

FIG. **42** is a perspective view of the attachment member applicable to the first output relay unit shown in FIG. **31** to FIG. **34** viewed from a rear side.

FIG. **43** is an illustration showing a condition in which the attachment member shown in FIG. **41** and FIG. **42** is applied.

DESCRIPTION OF THE EMBODIMENTS

Hereafter, referring to the attached drawings, a detailed description will be given of a preferred embodiment of an inverter device according to the invention.

FIG. **1** is a perspective view showing an inverter device which is an embodiment of the invention. The inverter device illustrated here is configured to include an inverter stack **10** and a switchboard **50**. The inverter stack **10** includes an inverter circuit in the interior thereof, is transported by a transport cart **1**, as shown in FIG. **2**, and installed in the target switchboard **50**.

FIG. **3** and FIG. **4** each show the transport cart **1** applied to the inverter device shown in FIG. **1** and FIG. **2**, wherein FIG. **3** is a perspective view showing a state in which the transport cart **1** is viewed from the front, while FIG. **4** is a perspective view showing a state in which the transport cart **1** is viewed from a rear side.

As shown in FIG. **3** and FIG. **4**, the transport cart **1** is configured of a support surface **3**, rail guides (guide members) **4**, a fixing plate (fixing and supporting member) **5**, and gripping portions **6** provided on a base **2** including a plurality of (for example, four) cart casters **1***a*.

The support surface **3** is configured of a steel plate, or the like, on the upper surface of the base **2**, and is a surface on which casters **10***a* provided on a bottom portion of the inverter stack **10** can roll. The support surface **3** supports the inverter stack **10** in a condition in which the inverter stack **10** is mounted. As shown in FIG. **5**, the support surface **3** has a height level the same as that of two mounting surfaces **51** of the inverter stack **10** in the switchboard **50**, that is, surfaces on which the casters **10***a* of the inverter stack **10** can roll.

A protruding portion **3***a* is provided on this kind of support surface **3**. The protruding portion **3***a* is a plate-shaped portion formed so as to protrude backward from a rear edge portion of the support surface **3**. The size of the left-to-right width of the protruding portion **3***a* corresponds to the distance between the two mounting surfaces **51** in the switchboard **50**, and when bringing the transport cart **1** into proximity from the front, positioning in a horizontal direction is carried out by the protruding portion **3***a* entering an entrance portion **52** of the switchboard **50** formed between the mounting surfaces **51**, as shown in FIG. **5**.

The rail guides **4** are elongated plate-shaped bodies extending in a longitudinal direction on both left and right ends of the support surface **3**. The rail guides **4** are fixed to the support surface **3** with screws, or the like. The rail guides **4** of this kind guide the rolling of the casters **10***a* of the inverter stack **10** when the inverter stack **10** supported in a mounted condition by the support surface **3** is moved toward the switchboard **50**, and restrict deviation in a horizontal direction of the inverter stack **10**.

The fixing plate **5** is a plate-shaped body provided so as to stand upright from the base **2** on the front side of the support surface **3**. A plurality of (for example, two) screw holes **5***a* is formed in the fixing plate **5**. When the inverter stack **10** is supported in a mounted condition by the support surface **3**, the screw holes **5***a* are provided corresponding one each to screw holes **10***b* formed in a lower front surface of the inverter stack **10**. Because of this, when the inverter stack **10** is supported by the support surface **3**, screws N**1** are inserted from the front through both the screw holes **5***a* of the fixing plate **5** and the screw holes **10***b* of the inverter stack **10**, and the fixing plate **5** is fastened to the inverter stack **10** by tightening the screws N**1** by rotating them around the axes thereof.

That is, the fixing plate **5** fixes and supports the inverter stack **10** by being fastened to the inverter stack **10** supported by the support surface **3** via fastening members such as the screws N**1**.

The gripping portions **6** are formed so as to form a left-right pair on the base **2**. The gripping portions **6** are configured by appropriately bending pipes, which are elongated rod-shaped

bodies, and connecting both ends of each pipe to the base **2** by welding or the like, and are gripped by the user, that is, the conveyor of the inverter stack **10**. References **7** in FIG. **3** and FIG. **4** are stoppers, and are provided on the gripping portions **6**.

The inverter stack **10** mounted on and supported by the support surface **3** of this kind of transport cart **1** is conveyed to the front of the switchboard **50** in which the inverter stack **10** is to be installed, as shown in FIG. **2**, and positioning is subsequently carried out by the transport cart **1** being brought into proximity with the switchboard **50**, and the protruding portion **3***a* being entered into the predetermined entrance portion **52** of the switchboard **50**. Then, the screws N1 inserted through the screw holes **5***b* and **10***b* of the fixing plate **5** and inverter stack **10** are removed, thus releasing the fastening of the fixing plate **5** and inverter stack **10**, and the inverter stack **10** can be housed in the switchboard **50** as shown in FIG. **1** by the inverter stack **10** being moved and entered from the front of the switchboard **50**.

FIG. **6** is a perspective view showing a housing bottom portion of the switchboard **50** shown in FIG. **1** and FIG. **2** in which the inverter stack **10** is housed, FIG. **7** is a perspective view showing an enlargement of a main portion of the housing bottom portion shown in FIG. **6**, and FIG. **8** is an illustration showing a state in which the housing bottom portion of the switchboard **50** shown in FIG. **6** is viewed from the side. As shown in FIG. **6** to FIG. **8**, the switchboard **50** includes an output relay terminal **53**.

A plurality (for example, three) of the output relay terminal **53** being provided, a U-phase output relay terminal **53**, a V-phase output relay terminal **53**, and a W-phase output relay terminal **53** are provided extending in the inverter stack **10** entry direction, that is, the longitudinal direction, and are provided in the housing bottom portion of the switchboard **50** so as to be aligned in parallel across insulators **54**. A rear surface end portion **531** of each of the output relay terminals **53** bends downward, and an output wire **55** connected to a load such as, for example, a motor, is attached to each rear surface end portion **531**. Also, a through hole **532***a* is formed in a front surface end portion **532** of each of the output relay terminals **53**, and a nut **532***b* is fixed and supported on the lower surface corresponding to the relevant through hole **532***a*.

The output relay terminals **53** are positioned lower than a bottom portion of the inverter stack **10** to be housed, or more specifically, She output relay terminals **53** are in a position at a height level lower than that of the casters **10***a* of the inverter stack **10**.

FIG. **9** is a perspective view showing the inverter stack **10** configuring the inverter device shown in FIG. **1** and FIG. **2**. The inverter stack **10** is configured to include a lower frame **20**, an inverter main body **30**, and a fan block **40**. The lower frame **20** configures the bottom portion of the inverter stack **10**, and has the heretofore described casters **10***a*. Although a detailed description will be given hereafter, the lower frame **20** is formed of a plurality of frame members **21** linked by screwing, or the like, so as to form the sides of a cuboid.

The inverter main body **30** is a housing incorporating in the interior thereof various circuits, such as an inverter circuit. An aperture **31** is formed in the upper surface of the inverter main body **30**, as shown in FIG. **10**. Two protruding pieces **321** protruding frontward are formed on a rear edge portion **32** of the upper surface of the inverter main body **30** in which this kind of aperture **31** is formed. Also, a plate spring member **322** is fixed by fastening with screws, or the like, to the rear edge portion **32**. A leading end portion **322***a* of the plate spring member **322** is of a form bent downward, and the leading end portion **322***a* enters a rectangular through hole **323** formed in the rear edge portion **32** from above.

Also, the inverter main body **30** is formed such that two slots **331** whose horizontal direction is the longitudinal direction are formed in an upper front surface **33** connected to the upper surface in which the aperture **31** is formed. Body portions **60***a* of bolt members **60** are passed through the slots **331** from the front, wherein the body portions **60***a* passing through the slots **331** are screwed into nuts **612** fixed to a plate member **61** so as to pass through through holes **611**, larger than the slots **331**, formed in the plate member **61**, which is an elongated plate-like body. Also, although not shown in FIG. **10**, stopper nuts **62** are fixed to leading end portions **60***b* of the bolt members **60** (refer to FIG. **18** and FIG. **19**).

The fan block **40** is disposed on an upper portion of the inverter main body **30**, and is of a box form in the interior of which are housed a plurality of fans F for sending air to the inverter main body **30**. The fan block **40** forms a cuboid form of which the upper surface and lower surface are opened, as shown in FIG. **11**.

An engagement hole **41**, a flange **42**, and a latch hole **43** are formed in this kind of fan block **40**. A plurality (for example, two) of the engagement hole **41** is formed in a lower front surface of the fan block **40**, that is, in the front surface of a portion extending downward from an extended end portion extending forward from a lower end portion of the front surface of the fan block **40**. The engagement holes **41** are of a keyhole shape wherein an attachment hole portion **411**, of a diameter larger than that of a head portion **60***c* of the bolt member **60**, and a clamping hole portion **412**, of a diameter smaller than that of the head portion **60***c* of the bolt member **60**, are formed so as to be continuous.

The flange **42** is formed so as to extend downward at the rear side of a left-right lower side edge portion forming a lower surface aperture **40***a* of the fan block **40**. The latch hole **43** is formed in the rear surface of the fan block **40**, and is of a size such as to allow the protruding piece **321** to be inserted through.

This kind of fan block **40** is engaged with and disposed on the inverter main body **30** in the following way. The fan block **40** is slid over the upper surface of the inverter main body **30** from the front toward the rear so that the head portions **60***c* of the bolt members **60** relatively pass through the attachment hole portions **411** of the engagement holes **41**, as shown in FIG. **12**. At this time, the flange **42** of the fan block **40** is positioned inward of an upper side edge portion **34** of the upper surface of the inverter main body **30** in which the aperture **31** is formed, as shown in FIG. **13** and FIG. **14**, preventing the sliding fan block **40** from deviating more than necessary in a horizontal direction.

Then, the protruding piece **321** of the inverter main body **30** is relatively inserted through the latch hole **43** of the fan block **40**, as shown in FIG. **15**, and the rear side of the fan block **40** engages with the inverter main body **30** by the leading end portion **322***a* of the plate spring member **322** holding down a rear extending portion **44** extending backward from a lower end portion of the rear surface of the fan block **40** with its own elastic restoring force, as shown in FIG. **16**.

Subsequently, the front side of the fan block **40** engages with the inverter main body **30**, as shown in FIG. **17** to FIG. **19**, by the bolt members **60** being displaced in a horizontal direction so that the head portions **60***c* thereof move from the attachment hole portions **411** to the clamping hole portions **412**, and the bolt members **60** being tightened. By so doing, it is possible to dispose the fan block **40** on the upper surface of the inverter main body **30**.

Meanwhile, this kind of fan block **40** is removed from the inverter main body **30** in the following way. A connector CN attached to the fan block **40** is removed, thereby releasing the tightening force of the bolt members **60**, as shown in FIG. **20**. Subsequently, the bolt members **60** are displaced in a horizontal direction so that the head portions **60***c* thereof move from the clamping hole portions **412** to the attachment hole portions **411**, as shown in FIG. **21**. Then, the fan block **40** is removed from the inverter main body **30** by the fan block **40** being pulled out to the front side, as shown in FIG. **22**.

That is, between the inverter main body **30** and fan block **40**, the bolt members **60**, engagement holes **41**, protruding pieces **321**, latch hole **43**, and plate spring member **322** configure engagement means that causes the fan block **40** to engage with the inverter main body **30**. In particular, the bolt members **60** and engagement holes **41** are formed such that, when the bolt members **60** are tightened in a condition wherein the body portions **60***a* of the bolt members **60** are passed through the clamping hole portions **412** of the engagement holes **41**, the fan block **40** is engaged with the inverter main body **30**, while when the body portions **60***a* are passed through the attachment hole portions **411** of the engagement holes **41** by the tightening force of the bolt members **60** being released and the bolt members **60** being slid in a horizontal direction relative to the engagement holes **41**, the fan block **40** is allowed to be disengaged from the inverter main body **30** by being pulled out to the front side.

The inverter stack **10** having this kind of configuration is housed and installed in the switchboard **50** in the following way.

FIG. **23** is a perspective view showing an input side connection condition of the inverter stack **10** and switchboard **50**, while FIG. **24** is an enlarged perspective view showing an enlargement of a main portion shown in FIG. **23**. As shown in FIG. **23** and FIG. **24**, the inverter stack **10** is formed such that two input terminals **35** provided on the inverter main body **30** are each linked via an input relay bar **70** to an input side terminal **56** of the switchboard **50**.

The input relay bar **70** is a plate-shaped member that links the input side terminal **56** and input terminal **35** as heretofore described by an upper end portion thereof being fastened via fastening members T to the corresponding input side terminal **56** of the switchboard **50** and a lower end portion thereof being fastened via fastening members T to the corresponding input terminal **35** of the inverter stack **10**.

Further, in each input relay bar **70**, cutouts **72** are formed communicating with the same side portion (the right side portion or left side portion) in hole portions **71** through which bolts, which are the fastening members T, pass.

As the cutouts **72** are formed in the hole portions **71** of the input relay bar **70** in this way, it is possible to disengage the input relay bar **70**, without removing the fastening members T, by releasing the tightening force of the fastening members T, as shown in FIG. **25**.

FIG. **26** is a perspective view showing an output side connection condition of the inverter stack **10** and switchboard **50**. As shown in FIG. **26** and also in the heretofore described FIG. **8**, three output terminals (not shown) provided on the inverter main body **30** are each linked via an output relay bar **73** to the front surface end portion **532** of the output relay terminal **53** of the switchboard **50**. Herein, three of the output relay bar **73** being provided, there is one that links a U-phase output terminal and the U-phase output relay terminal **53**, one that links a V-phase output terminal and the V-phase output relay terminal **53**, and one that links a W-phase output terminal and the W-phase output relay terminal **53**.

Each of this kind of output relay terminal bar **73** has the same configuration, and includes a first output relay bar **731** and second output relay bar **732**. The first output relay bar **731** extends in a vertical direction, and an upper end portion thereof is linked to the corresponding output terminal.

The second output relay bar **732** has an L-shaped longitudinal section form, and more specifically, has a base portion **7321** and leading end portion **7322**, as shown in FIG. **27**. The base portion **7321** is a region extending in a vertical direction and protruding downward from the bottom portion of the inverter stack **10**, wherein an upper end portion thereof is fastened via a fastening member T to a lower end portion of the first output relay bar **731**. The leading end portion **7322** is a region extending forward from a lower end portion of the base portion **7321**, and is fastened via a fastening member T to the front surface end portion **532** of the corresponding output relay terminal **53**. That is, the output relay terminal **53** provided in the switchboard **50** is formed such that the output wire **55** connected to a load such as a motor is attached to the rear surface end portion **531**, and the front surface end portion **532** is linked to the output terminal of the inverter stack **10** and fastened via a fastening member T to the output relay bar **73** protruding downward from the bottom portion of the inverter stack **10**.

An insertion hole **7321***a* in the base portion **7321** through which the fastening member T is inserted, and an insertion hole **7322***a* in the leading end portion **7322** through which the fastening member T is inserted, are formed in this kind of second output relay bar **732** so as to have a diameter larger than the outer diameter of the fastening member T.

Because of this, it is possible to absorb dimensional tolerance in a horizontal direction and vertical direction with the insertion hole **7321***a* of the base portion **7321**, and possible to absorb dimensional tolerance in a horizontal direction and longitudinal direction with the insertion hole **7322***a* of the leading end portion **7322**.

Also, the output relay bar **73** is formed such that it is possible to implement the setting up of a single inverter that inspects the drive of the inverter stack **10** by removing the second output relay bar **732** from both the first output relay bar **731** and the corresponding output relay terminal **53**, as shown in FIG. **28**.

As the output relay bar **73** is provided so as to pass through the lower frame **20** of the inverter stack **10**, the lower frame **20** is formed such that the frame members **21** configuring one side of a four-sided frame through which the output relay bar **73** passes, that is, the frame member **21** configuring a front upper side and the frame member **21** configuring a front lower side, are formed of a non-magnetic body such as, for example, stainless steel, while the other frame members **21** are formed of sheet-metal, or the like, as shown in FIG. **29**.

By the frame members **21** configuring one side of the four-sided frame through which the output relay bar **73** passes being formed of a non-magnetic body in this way, it is possible to control the occurrence of an overcurrent.

In FIG. **29**, the frame member **21** configuring the front upper side and the frame member **21** configuring the front lower side are formed of a non-magnetic body as one side of the four-sided frame through which the output relay bar **73** passes, but the lower frame **20** of the embodiment is formed such that a front portion **23** of the lower frame **20**, formed of longitudinal frame members **22** configuring a left-right pair of front longitudinal sides linking the frame member **21** configuring the front upper side and the frame member **21** configuring the front lower side, may be formed of a non-magnetic body such as, for example, stainless steel, as shown in FIG. **30**.

With this kind of configuration too, by the frame members **21** configuring one side of the four-sided frame through which the output relay bar **73** passes being formed of a non-magnetic body, it is possible to control the occurrence of an overcurrent.

The heretofore described inverter device is formed such that the output relay bars **73** are an output relay unit, wherein one linking the U-phase output terminal and U-phase output relay terminal **53**, one linking the V-phase output terminal and V-phase output relay terminal **53**, and one linking the W-phase output terminal and W-phase output relay terminal **53** are shown, but in the embodiment, an output relay unit alternatively selected from a first output relay unit **80** and second output relay unit **90** may be used as the output relay unit instead of the output relay bar **73**.

Each of FIG. **31** to FIG. **34** shows the first output relay unit **80**, wherein FIG. **31** is a front view, FIG. **32** is a side view, FIG. **33** is a perspective view viewed from the front, and FIG. **34** is a perspective view viewed from the rear.

The first output relay unit **80** illustrated here includes three output relay bars **81** and a fixing plate **82**. The three output relay bars **81** are one that links the U-phase output terminal and the U-phase output relay terminal **53**, one that links the V-phase output terminal and the V-phase output relay terminal **53**, and one that links the W-phase output terminal and the W-phase output relay terminal **53**.

The three output relay bars **81** include a first output relay bar **811** and second output relay bar **812**. The first output relay bar **811** extends in a vertical direction, and an upper end portion thereof can be linked to the corresponding output terminal. The second output relay bar **812** has an L-shaped longitudinal section form, and more specifically, has a base portion **8121** and leading end portion **8122**. The base portion **8121** extends in a vertical direction, and an upper end portion thereof is fastened via a fastening member T to a lower end portion of the first output relay bar **811**. The leading end portion **8122** is a region extending forward from a lower end portion of the base portion **8121**, and can be fastened via a fastening member T to the front surface end portion **532** of the corresponding output relay terminal **53**. Further, an insertion hole (not shown) in the base portion **8121** through which the fastening member T is inserted, and an insertion hole **8122***a* in the leading end portion **8122** through which the fastening member T is inserted, are formed in the second output relay bar **812** so as to have a diameter larger than the outer diameter of the fastening member T.

The fixing plate **82** is configured by carrying out an appropriate bending process on sheet-metal, and is integrally linked with the three output relay bars **81** across resin **80***a*, which is an insulating member, thereby forming a unit. This kind of fixing plate **82** is for fixing the first output relay unit **80** in the inverter stack **10**. References **83** in FIGS. **31** to **34** are Hall effect current transformers, and carry out current detection.

As this kind of first output relay unit **80** has the three output relay bars **81**, the three phases of output from the output terminals can be output as they are to the output relay terminals **53**.

Each of FIG. **35** to FIG. **38** shows the second output relay unit **90**, wherein FIG. **35** is a front view, FIG. **36** is a side view, FIG. **37** is a perspective view viewed from the front, and FIG. **38** is a perspective view viewed from the rear.

The second output relay unit **90** illustrated here includes one output relay bar **91** and a fixing plate **92**. The output relay bar **91** includes a first output relay bar **911** and second output relay bar **912**. The first output relay bar **911** extends in a vertical direction, and an upper end portion thereof can be linked to the three output terminals.

The second output relay bar **912** has an L-shaped longitudinal section form, and more specifically, has a base portion **9121** and leading end portion **9122**. The base portion **9121** extends in a vertical direction, and an upper end portion thereof is fastened via a fastening member T to a lower end portion of the first output relay bar **911**. The leading end portion **9122** is a region extending forward from a lower end portion of the base portion **9121**, and can be fastened via a fastening member T to the front surface end portion **532** of any output relay terminal **53**. Further, an insertion hole (not shown) in the base portion **9121** through which the fastening member T is inserted, and an insertion hole **9122***a* in the leading end portion **9122** through which the fastening member T is inserted, are formed in the second output relay bar **912** so as to have a diameter larger than the outer diameter of the fastening member T.

The fixing plate **92** is configured by carrying out an appropriate bending process on sheet-metal, and is integrally linked with the output relay bar **91** across resin **90***a*, which is an insulating member, thereby forming a unit. This kind of fixing plate **92** is for fixing the second output relay unit **90** in the inverter stack **10**. References **93** in FIGS. **35** to **38** are Hall effect current transformers, and carry out current detection.

As this kind of second output relay unit **90** has the one output relay bar **91**, the three phases of output from the output terminals can be output to the output relay terminals **53** as a single phase, which is one of the U-phase, V-phase, or W-phase.

Further, the first output relay unit **80** may be used as the output relay unit by fixing it to the lower frame **20** of the inverter stack **10** via the fixing plate **82** and fastening the output relay bars **81** to the output terminals and output relay terminals **53**, as shown in FIG. **39**, or the second output relay unit **90** may be used as the output relay unit by fixing it to the lower frame **20** of the inverter stack **10** via the fixing plate **92** and fastening the output relay bar **91** to the output terminals and one of the output relay terminals **53**, as shown in FIG. **40**.

As heretofore described, the transport cart **1** is formed such that the support surface **3** that supports the inverter stack **10** in a mounted condition has a height level the same as that of the inverter stack **10** mounting surfaces **51** in the switchboard **50** in which the inverter stack **10** is to be installed, and positioning in a horizontal direction is carried out by the protruding portion **3***a* provided so as to protrude outward from the support surface **3** entering the entrance portion **52** of the switchboard **50** formed between the mounting surfaces **51**, because of which there is no need for high positioning accuracy, as there is with a heretofore used lifter. Moreover, there is no need for a mechanism, or the like, that moves a support base in a vertical direction, as there is with a lifter. Consequently, according to the transport cart **1**, it is possible to more easily install the inverter stack **10** in the switchboard **50**, while achieving a reduction in cost.

Also, according to the transport cart **1**, the rail guides **4** disposed on the support surface **3** in the direction in which the inverter stack **10** can move restrict deviation in a horizontal direction with respect to the direction of movement when moving the inverter stack **10**, because of which it is possible to carry out the inverter stack **10** installation work well.

Furthermore, according to the transport cart **1**, the inverter stack **10** is fixed and supported by the fixing plate **5** standing upright from the support surface **3** being fastened via fastening members such as the screws N1 to the inverter stack **10** supported by the support surface **3**, because of which it is possible to prevent the inverter stack **10** from falling even during transportation.

Further still, according to the transport cart **1**, the gripping portions **6** are provided so as to form a left-right pair on the base **2** including the support surface **3**, because of which it is possible to transport the inverter stack **10** well, even in a narrow passage, or the like.

The inverter stack **10** is formed such that, when the bolt members **60** are tightened in a condition wherein the body portions **60***a* of the bolt members **60** are passed through the clamping hole portions **412** of the engagement holes **41**, the fan block **40** is engaged with the inverter main body **30**, while when the body portions **60***a* are passed through the attachment hole portions **411** of the engagement holes **41** by the tightening force of the bolt members **60** being released and the bolt members **60** being slid in a horizontal direction relative to the engagement holes **41**, the fan block **40** is allowed to be disengaged from the inverter main body **30** by being pulled out to the front side, because of which it is possible to disengage the fan block **40** from the inverter main body **30** even when the width of the housing region in which the inverter stack **10** is installed is small, and thus possible to easily carry out the work of removing the fan block **40**. In particular, according to the inverter stack **10**, the stopper nuts **62** are fixed to the leading end portions **60***b* of the bolt members **60**, because of which the bolt members **60** do not fall out even when the tightening force of the bolt members **60** is released. Consequently, it is possible to prevent the bolt members **60** from falling out when disengaging the fan block **40** from the inverter main body **30**.

Also, according to the inverter stack **10**, when the fan block **40** is disposed on the upper surface of the inverter main body **30**, the protruding piece **321** of the inverter main body **30** is inserted through the latch hole **43** of the fan block **40**, and furthermore, the rear extending portion **44** of the fan block **40** is held down by the plate spring member **322** attached to the inverter main body **30**, because of which it is sufficient simply to push the fan block **40** in toward the rear, and thus possible to carry out the fan block **40** installation work well.

The heretofore described inverter device is formed such that the output relay terminals **53** are provided so as to extend in the inverter stack **10** entry direction in the housing bottom portion in which the inverter stack **10** is housed, the output wire **55** connected to a load such as a motor is attached to the rear surface end portion **531**, and the front surface end portion **532** is linked to the output terminal of the inverter stack **10** and fastened via the fastening member T to the output relay bar **73** protruding downward from the bottom portion of the inverter stack **10**, because of which it is possible to release the output side connection condition of the inverter stack **10** and switchboard **50** simply by releasing the fastenings of the output relay terminals **53** and output relay bars **73**. Consequently, according to the inverter device, it is possible to easily remove the inverter stack **10** from the switchboard **50**.

Also, according to the inverter device, the input relay bar **70** is formed such that, as the fastening members T, such as bolts, are inserted through the hole portions **71** in which are formed the cutouts **72** communicating with the same side portion, it is possible to disengage the input relay bar **70**, without removing the fastening members T, by releasing the tightening force of the fastening members T, and thus possible to release the input side connection condition of the inverter stack **10** and switchboard **50**. Consequently, for this reason too, it is possible to easily remove the inverter stack **10** from the switchboard **50**.

Furthermore, according to the inverter device, the lower frame **20** configuring the inverter stack **10** is formed such that, as the frame members **21** configuring one side of the four-sided frame through which the output relay bar **73** passes are formed of a non-magnetic body, it is possible to control the occurrence of an overcurrent, because of which it is possible to prevent heating and vibration due to the occurrence of an overcurrent, or the like. Also, as the other frame members **21** of the lower frame **20** are configured of sheet-metal or the like, it is possible to reduce manufacturing cost in comparison with when forming all the frame members of a non-magnetic body such as stainless steel. Consequently, it is possible to achieve a reduction in manufacturing cost while preventing heating and vibration due to the occurrence of an overcurrent, or the like. Provided that it is clear that no overcurrent due to the magnitude of the current transmitted through the output relay bar **73** will occur in the lower frame **20**, the frame members **21** formed of a non-magnetic body may be replaced with frame members formed of a magnetic body such as sheet-metal. When it is clear in this way that no overcurrent will occur, it is possible to achieve a reduction in operational cost by configuring all the frame members **21** configuring the lower frame **20** of a magnetic body.

Further still, according to the inverter device, it is possible to use an output relay unit alternatively selected from the first output relay unit **80** and second output relay unit **90** as the output relay unit instead of the output relay bar **73**, because of which it is possible to easily carry out a change in the output terminal configuration linking the inverter stack **10** and switchboard **50**.

Heretofore, a description has been given of a preferred embodiment of the invention but, the invention not being limited to this, various changes can be carried out.

In the heretofore described embodiment, an output relay unit alternatively selected from the first output relay unit **80** and second output relay unit **90** is used as the output relay unit, but the invention is formed such that an output relay unit having the following kind of attachment member **84** may be used as a modification example of the first output relay unit **80**.

Each of FIG. **41** and FIG. **42** shows the attachment member **84**, which is applicable to the first output relay unit **80** shown in FIG. **31** to FIG. **34**, wherein FIG. **41** is a perspective view viewed from the front, while FIG. **42** is a perspective view viewed from the rear. The attachment member **84** illustrated here includes three output relay attachment bars **85**.

The three output relay attachment bars **85** include a first output relay attachment bar **851** and second output relay attachment bar **852**. The first output relay attachment bar **851** is formed to have a first base portion **8511** extending in a vertical direction, a right extending portion **8512** extending rightward from an upper end portion of the first base portion **8511**, and a left extending portion **8513** extending leftward from a lower end portion of the first base portion **8511**, wherein the first base portion **8511** is linked to an attachment fixing plate **86** across resin **84***a*, which is an insulating member.

The second output relay attachment bar **852** is formed to have a second base portion **8521** extending in a vertical direction, a rear extending portion **8522** extending backward from an upper end portion of the second base portion **8521**, and a front extending portion **8523** extending forward from a lower end portion of the second base portion **8521**, wherein the rear extending portion **8522** is fastened via a fastening member T to the left extending portion **8513** of the first output relay attachment bar **851**.

This kind of attachment member **84** is used by fixing the attachment fixing plate **86** to the lower frame **20** of the inverter stack **10** and fastening the front extending portion **8523** of each second output relay attachment bar **852** to the

leading end portion **8122** of the corresponding second output relay bar **812** via a fastening member T, as shown in FIG. **43**.

By using the first output relay unit **80** including this kind of attachment member **84** as the output relay unit, it is possible to respond flexibly to customer demands and specification changes.

REFERENCE SIGNS LIST

1 Transport cart
1*a* Cart caster
2 Base
3 Support surface
3*a* Protruding portion
4 Rail guide (guide member)
5 Fixing plate (fixing and supporting member)
5*a* Screw
6 Gripping portion
10 Inverter stack
10*a* Caster
20 Lower frame
21 Frame member
30 Inverter main body
31 Aperture
32 Rear edge portion
321 Protruding piece
322 Plate spring member
322*a* Leading end portion
323 Through hole
33 Upper front surface
331 Slot
34 Upper side edge portion
35 Input terminal
40 Fan block
40*a* Lower surface aperture
41 Engagement hole
411 Attachment hole portion
412 Clamping hole portion
42 Flange
43 Latch hole
44 Rear extending portion
50 Switchboard
51 Mounting surface
52 Entrance portion
53 Output relay terminal
531 Rear surface end portion
532 Front surface end portion
532*a* Through hole
532*b* Nut
54 Insulator
55 Output wire
56 Input side terminal
60 Bolt member
60*a* Body portion
60*b* Leading end portion
60*c* Head portion
61 Plate member
611 Through hole
612 Nut
62 Stopper nut
70 Input relay bar
71 Hole portion
72 Cutout
73 Output relay bar
731 First output relay bar
732 Second output relay bar
7321 Base portion
7322 Leading end portion
7321*a* Insertion hole
7322*a* Insertion hole
80 First output relay unit
81 Output relay bar
80*a* Resin
811 First output relay bar
812 Second output relay bar
8121 Base portion
8122 Leading end portion
8122*a* Insertion hole
82 Fixing plate
84 Attachment member
84*a* Resin
85 Output relay attachment bar
851 First output relay attachment bar
8511 First base portion
8512 Right extending portion
8513 Left extending portion
852 Second output relay attachment bar
8521 Second base portion
8522 Rear extending portion
8523 Front extending portion
86 Attachment fixing plate
90 Second output relay unit
90*a* Resin
91 Output relay bar
911 First output relay bar
912 Second output relay bar
9121 Base portion
9122 Leading end portion
9122*a* Insertion hole
92 Fixing plate
F Fan
T Fastening member

What is claimed is:

1. An inverter device, comprising:
an inverter stack having
a lower frame configuring a bottom portion of the inverter stack and including a plurality of frame members connected to each other to form corner portions of a cuboid,
an output terminal, and
an output relay bar connected to the output terminal and passing through the lower frame; and
a switchboard housing the inverter stack,
wherein the frame members configuring a front side of a four-sided frame are formed of a non-magnetic body, and other frame members are formed of sheet metal.

2. An inverter device according to claim **1**, wherein one of the frame members configuring the front side of the frame constructing an upper side of the four-sided frame in the lower frame is formed of the non-magnetic body, and
one of the frame members configuring the front side of the frame constructing a lower side of the four-sided frame in the lower frame is formed of the non-magnetic body.

3. An inverter device according to claim **1**, wherein the lower frame includes a front portion comprising one of the frame members configuring the front side of the frame constructing an upper side of the four-sided frame in the lower frame, one of the frame members configuring the front side of the frame constructing a lower side of the four-sided frame in the lower frame, and longitudinal frame members connecting the one of the frame members in the upper side and one of the frame member in the lower side, and
the frame members forming the front portion are formed of the non-magnetic body.

4. An inverter device according to claim 1, wherein the output relay bar extends through a space between front, rear, and side frame members from a top side of the lower frame to a bottom side of the lower frame.

5. An inverter device according to claim 4, wherein the switchboard includes

an input terminal connected to the output terminal of the inverter stack, and

a housing bottom portion disposed below the input terminal and having an output relay terminal to connect to the output relay bar of the inverter stack.

6. An inverter device according to claim 5, wherein the output relay bar includes

a first output relay bar extending in a vertical direction of the inverter stack and connected to the output terminal; and

a second output relay bar having a base portion extending in the vertical direction to connect to the first output relay bar, and a leading end portion extending from the base portion in a direction perpendicular to that of the base portion and connecting to the output relay terminal of the switchboard.

7. An inverter device according to claim 6, wherein the inverter stack further comprises casters on the bottom portion thereof to move in or out from the switchboard, and

the output relay terminal is disposed at a height lower than that of the casters of the inverter stack.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,318,882 B2
APPLICATION NO. : 14/131780
DATED : April 19, 2016
INVENTOR(S) : Toshihiro Yoshida et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the specification

Please change column 5, line 46, from "specifically, She ..." to --Specifically, the ...--.

Signed and Sealed this
Twenty-eighth Day of June, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office